THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
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IDENTIFICATION SECTION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch Plant Industry Station, Beltsville, Maryland
Volume 40 November 15, 1956 Number 11

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A THERMISTOR-EQUIPPED PSYCHROMETER FOR PLANT RESEARCH

Richard D. Schein, Wm. E. Blumberg, and Robert R. Kooiman[1]

SUMMARY

A thermistor-equipped psychrometer suitable for field use in studying temperature and atmospheric moisture factors influencing development of epiphytotics is described. The instrument is characterized by portability, independent power source, small volume sampling, negligible disturbance of air in sampling area, and accuracy. Physical description of all elements, wiring diagrams, calibration characteristics, and methods of use are given.

INTRODUCTION

Throughout the literature on plant disease development there is an awareness by authors of the dependency of plant diseases upon weather factors, particularly temperature, atmospheric moisture, and rain. Very often, neither direct data were obtained nor controlled studies made of the interrelationship of these phenomena. Rather, because it was obvious a disease prospered in wet weather, observations were made of rainy spells and disease occurrence, but these were not always statistically correlated with infection, sporulation, etc. The tremendous amount of information thus obtained and reported, often as intercalary sentences or paragraphs in a paper, is not to be scorned, because from it has come a general understanding of the dependency of plant disease upon weather.

On the other hand, little field work has been published dealing directly with the effect of single meteorologic factors on disease development or on phases of pathogen development (germination, infection, sporulation) critical to an epiphytotic. Within the last five years, experimental approaches used to increase our understanding of these interrelationships have fallen into two general categories: 1) closely controlled laboratory studies and 2), field studies in which adroit use of hygrothermographs, thermocouples, maximum-minimum thermometers, and sling and motor-ventillated psychrometers has yielded significant and understandable data. Together, these researches have upheld some old generalizations, modified others, and added much important new knowledge to our understanding of plant disease development.

Nevertheless, there is a gap in our knowledge that is hardly explored and which can be illustrated rather easily. Hyre and Cox[2], studying Phytophthora phaseoli and Delp[3], studying Uncinula necator, have shown, in well-controlled laboratory experiments of quite different design, what combinations of atmospheric temperature and humidity are limiting and conducive to pathogen (and disease) development. But these researches do not indicate directly what happens in the field. It is necessary to determine when these prescribed conditions occur. The relationship of such knowledge to epidemiology and disease forecasting is obvious.

If one disregards the reports in which an adequate understanding of atmospheric moisture relations was lacking or, in other cases, where possibly good data were inadequately interpreted in the form of practically meaningless averages (e.g., mean monthly temperature, mean diurnal temperature), it is apparent that the gaps in our knowledge are due mostly to inadequate instrumentation. The hygrothermograph, an excellent instrument when employed within its limitations, tells little about conditions in an alfalfa stand when housed in a weather shelter 4 to 5 feet above the ground. Weather data taken by a station at the local airport or by the campus department of meteorology can be applied to a crop planting several miles away only with the utmost caution. Vast microclimatological differences separate the two areas and these differences may be extremely important to critical processes in disease development.

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[1] Respectively, Assistant Professor of Plant Pathology, Pennsylvania State University, Teaching Assistant in Physics, University of California, Berkeley, and Physical Sciences Research Assistant, Fort Detrick, Maryland.

[2] Hyre, R. A., and R. S. Cox. 1953. Factors affecting viability and growth of Phytophthora phaseoli. Phytopathology 43: 419-424.

[3] Delp, Charles J. 1954. Effect of temperature and humidity on the grape powdery mildew fungus. Phytopathology 44: 615-626.

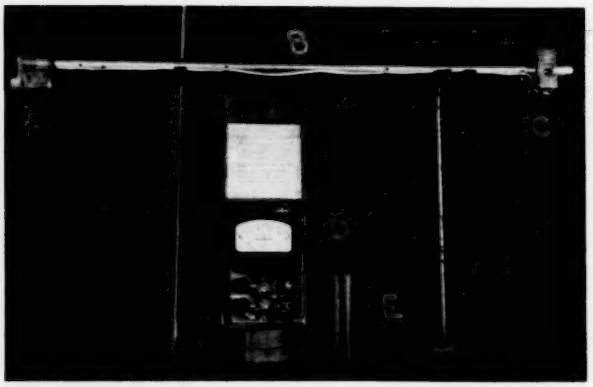

FIGURE 1. The thermistor-equipped psychrometer. (A) sampling head; (B) probe; (C) centrifugal exhaust fan; (D) control panel; (E) 6-volt dry cell for fan.

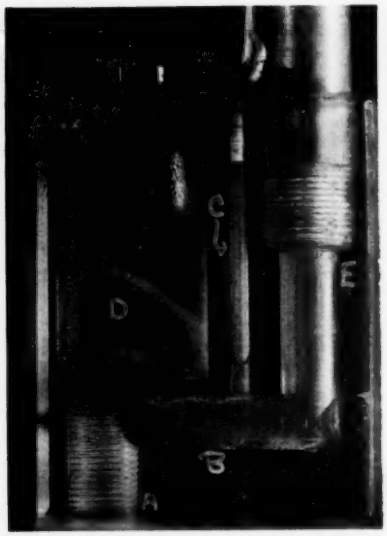

FIGURE 2. Sampling head of psychrometer. (A) extrance port; (B) horizontal air channel; (C) thermistor channels; (D) water reservoir and wick; (E) exit channel.

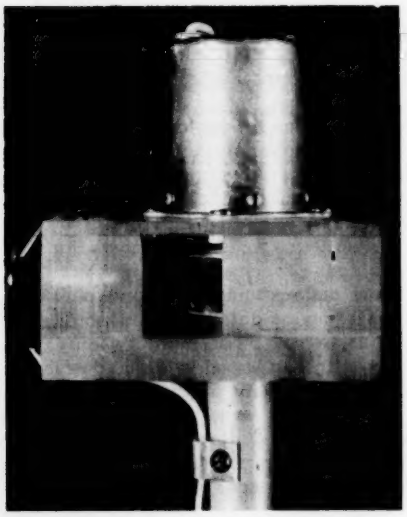

FIGURE 3. Centrifugal exhaust fan and motor.

FIGURE 4. Control box for psychrometer. Microampere scale is approximately 4 inches long. Calibration controls are inoperative.

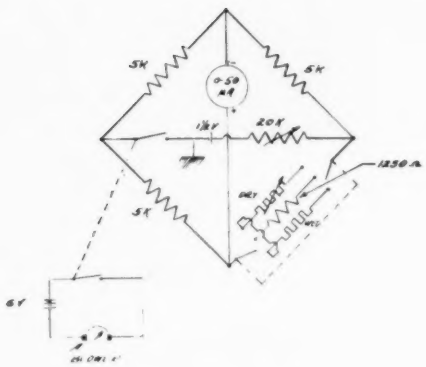

FIGURE 5. Wiring diagram for thermistor-equipped psychrometer.

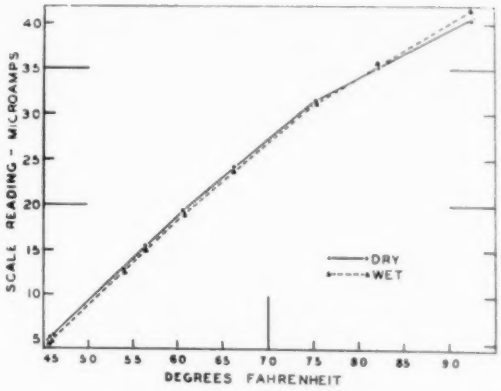

FIGURE 6. Sample calibration curves for wet and dry thermistors.

Instruments which will accurately indicate or record atmospheric conditions in the plant foliosphere are fairly difficult and expensive to assemble, and are not obtainable from supply houses. The cost of the excellent equipment constructed by Thornthwaite at Seabrook Farms, New Jersey, is far beyond the research budgets of most schools and departments and this cost has undoubtedly been a deterrent to accurate research. In addition, this equipment is not readily adaptable to field use from a pathologist's viewpoint.

Lorenzen[4, 5] has described various possible assemblies for thermoelectric psychrometers employing thermocouples. Such instruments are sensitive and accurate but have inherent features which limit their portable field use. The thermistor-equipped psychrometer described below was designed to eliminate some of these features so that data could be obtained about the temperature and moisture content of the space around crop leaves during occurrence of rain, clear and cloudy nights, periods of dew, etc. Field circumstances dictated the following characteristics of the instrument: portability, independent power source, low volume air sampling, negligible disturbance of air in sampling area, and accuracy.

THERMISTOR-EQUIPPED PSYCHROMETER, PHYSICAL DESCRIPTION[6]

The sensing elements of the thermistor-equipped psychrometer (Fig. 1) are Western Electric bead thermistors designated "14-B". These thermistors exhibit a negative temperature-resistance relation which varies in an exponential manner. The units vary in resistance from approximately 900 ohms at 45° C to 5500 ohms at 0° C. The thermistor bead is enclosed in glass which serves as a supporting stem for the bead and leads. The thermistor units are about 1/8 inch O. D. and about 2 inches in length. One of the thermistors was equipped with a cotton psychrometer sock which encompasses the bead and about half of the glass supporting stem.

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[4] Lorenzen, C. 1941. Construction and use of a thermoelectric psychrometer. In Temperature, its measurement and control in science and industry. Reinhold, New York. pp. 660-665.

[5] Lorenzen, C. 1949. The thermocouple in agricultural research. Agricultural Engineering 30: 275-279.

[6] Scale drawings are available on loan from the senior author.

FIGURE 7. Elevator used in field studies allowing readings from 0-12 feet above the ground.

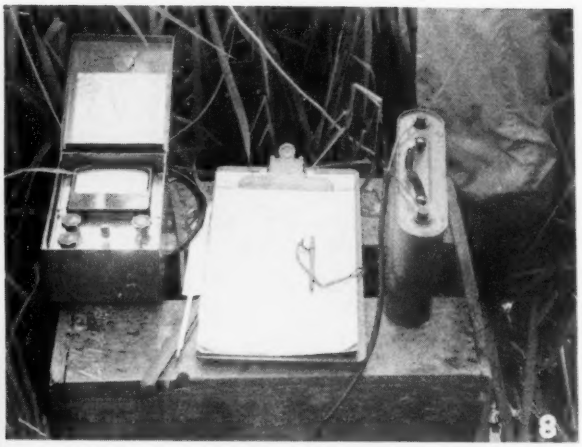

FIGURE 8. Arrangement of control box, battery, and data sheet used in field studies.

Both thermistors are mounted in a 2-7/8 x 2-1/4 x 1-1/4-inch sampling head which was machined from clear Lucite (Fig. 2). Air enters the head vertically through a 3/8-inch hole (Fig. 2, A), is channelled horizontally 1-3/8 inches (Fig. 2, B), and leaves the sampling head through another vertical channel (Fig. 2, E). The wet thermistor and sock protrude approximately 1/8 inch into the main body of the horizontal air stream and the dry thermistor is exposed to a 1/4 inch air stream which bypasses the main channel to avoid moisture contamination by the wet sock. The sampling head also contains a 1 cubic-inch water reservoir for the wet thermistor (Fig. 2, D). This is sufficient water to operate the instrument continuously for several hours.

Two types of probes are provided which can be screwed into the air intake hole in the head. One is simply a tube 2 inches in length which collects air from all directions. The other is fitted with two horizontal discs separated by 1/4 inch. This probe collects air from a level adjacent to the perimeter of the discs.

Air is drawn through the sampling head by a miniature 6-volt d. c. motor and centrifugal blower mounted on top of a 5/8 inch O. D. aluminum tube which supports the sampling head (Fig. 3). By means of the tube, the exhaust from the blower is kept 36 inches away from the head in order not to contaminate the sampling area. The blower is of a nominal 2 cubic feet per minute capacity, but owing to the constrictions in the sampling head, less than 0. 5 c. f. m. passes through the instrument.

The electrical connections to the thermistors are made through a cable to a bridge box. The bridge is a 6 x 10 x 4-inch cut-off switch box into which has been placed a panel for the meter and controls (Fig. 4). The bridge circuit is a Wheatstone bridge system indicating unbalanced into a 0-50 microampere meter. Power for the measuring circuit is supplied by a 1. 5-volt size D dry cell. A variable resistance is in series with the battery and bridge and is adjusted so that the meter reads full scale when a calibrating resistor is switched into the measuring circuit. Figure 5 is the wiring diagram. Resistive characteristics of the sensing thermistors were adjusted by adding fixed resistors in shunt and series to make the temperature-resistance characteristics of each sensor approximately equal. Final calibration curves were made of each thermistor after installation, and values in microamperes are referred to the calibration curves to obtain actual temperatures. Response times of the wet and dry units are less than 1 minute and internal heating due to current flow through the thermistors is small enough to be negligible at normal ambient temperatures.

To operate, the toggle "off-on" switch is turned on to start the centrifugal fan, power for which is derived from a 6-volt dry cell. The thermistor switch is moved to "check" and the

"full-scale" knob turned to adjust the meter reading to 50 microamps. The switch is then moved alternately to engage the wet and dry thermistors until the operator is satisfied by the consistency of consecutive readings.

The instrument may be used on an elevator as shown in Figure 7 or hand-held by the operator or an assistant. With these methods, temperature and humidity profiles of crop-growing fields have been obtained which show the effect of crop cover and also of uninterrupted radiation and many other factors. Leaf temperatures are not obtainable through its use but readings can be made of temperature and humidity of small volumes within and outside the foliosphere.

CALIBRATION

Because the instrument reads in microamperes and not in degrees Fahrenheit, calibration was necessary before field use could be attempted. This was accomplished through use of a water pan equipped with a mechanical stirrer. Water at approximately 95° F was placed in the pan and agitation begun. Three immersion thermometers served as a temperature reference. The sampling head of the psychrometer was placed into the water so that the sensing portions of the thermistors were immersed. When equilibrium was attained, a series of readings were taken with both the "wet" and "dry" thermistors. When several readings agreed within 0.1 microamps, the sampling head was withdrawn, some of the water was replaced with cooler water until a temperature a few degrees lower was attained. After ascertaining that no water remained in the sampling head air channel, the head was reimmersed and more readings taken. This was repeated until a curve could be drawn showing the response of the two thermistors over the usable range of temperatures (45° to 95° F). Figure 6 is a calibration curve resulting from this technique.

USES OF THE INSTRUMENT

This kind of instrument has manifold potential uses. It was designed to obtain field data not easily obtainable by other means. Most obvious of its uses to the plant pathologist is in the study of moisture relations inside the plant foliosphere in determining the moisture requirements of particular pathogens for activities vital to development of ephiphytotics. Figures 7 and 8 illustrate field use of this type.

By re-design of the wiring and resistance, studies in a much smaller range of temperatures could be accomplished on an expanded and thus more accurate microampere scale.

ACCURACY

It is very difficult to test the accuracy of such an instrument because of lack of equipment and lack of an adequate reference. Tested against a motor-ventilated mercury-in-glass psychrometer, it shows a maximum variance of 1.5 percent relative humidity in the humidity range 54 to 84 percent in a temperature range of 70° to 90° F. In field use, under conditions of near or complete moisture saturation, the instrument showed great stability and sensitivity to the slightest changes brought on by air turbulence. Use following an accurate and painstaking calibration should yield consistent, accurate, and useful data.

PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PENNSYLVANIA; UNIVERSITY OF CALIFORNIA; BERKELEY, CALIFORNIA, AND FORT DETRICK, MARYLAND

TRANSMISSION OF THE STEM PITTING FACTOR IN APPLE[1]

H. W. Guengerich and D. F. Millikan[2]

Abstract

The stem pitting factor in apple has been experimentally transmitted by buds and bits of bark from pitted to non-pitted apple trees. This confirms the virus nature of this disorder suggested previously in transmission studies involving hosts other than apple.

Pitting of the Virginia Crab stem piece in double grafted apple trees has been reported by Miller (2) and Smith (5). Tukey et al. (6) list 20 varieties and color sports, including all of the commercially important varieties, showing this abnormality. The possibility of virus infection was suggested in their reports and the disorder was likened by Smith to that caused by the quick decline virus in citrus. Observations in many sections of the United States and Canada by the authors indicated that this wood pitting is usually associated with bark cracking, dwarfed growth, and early fruitful production, but the intensity of these symptoms varied from extremely mild to very severe. Trees of the same variety with Virginia Crab interstocks have been observed with no pitting on the stem piece. Such trees are almost invariably larger than trees of the same variety and age, grafted directly on seedling roots.

The first indication that an infectious entity might be involved in this disorder was reported by Millikan and Guengerich (3) when buds from a diseased apple chip-budded on Prunus tomentosa seedlings caused a striking mottle on the subsequent foliage. Amelanchier spp. (4) was shown to be susceptible to the entity and the possibility of using this genus as an indicator was considered. Simultaneously, Hilborn (1) reported successful transmission to Datura, an herbaceous host.

History of the Experimental Material

In 1942, Golden Delicious from two separate sources were budded into the scaffold branches of Virginia Crab that had been planted in regular orchard distances the previous spring. Although, as said, two different sources of Golden Delicious budwood were used, the Virginia Crab source represented a single lot purchased from a nursery. Since the budwood sources differed, the resulting two groups are referred to as Lot A and Lot B in this manuscript. Lot A grew vigorously and first fruited in 1947, whereas Lot B grew moderately but bore heavily 2 years earlier. The trees of Lot A have continued to grow and have developed into large orchard trees. On the other hand, trees from Lot B have remained markedly smaller and have not increased appreciably in trunk caliper during the past 3 years. The Virginia Crab stem pieces of both lots were examined critically in 1953 and compared for gross morphology. The bark of the trees in Lot A was smooth and the wood showed no pitting, but the bark on trees of Lot B was rough and cracked and the wood showed heavy pitting.

Experimental Methods

Water sprouts of Virginia Crab developing from the stem piece of a tree from Lot A were collected in 1954 and 1955 and propagated by bench grafting on western apple seedlings normally used in nursery propagation. These served as indicator hosts for the transmission studies.

In July 1954, buds from both sources of Golden Delicious were budded into separate Virginia Crab stocks propagated from the disease-free source. The buds were placed approximately 8 inches from the ground and developed into vigorous trees during the 1955 season. In September 1955, these trees were dug and the bark peeled from the Virginia Crab section and the wood examined for pitting. Buds from a double-worked Early Harvest tree, the Virginia Crab trunk of which showed severe pitting, were used in the same manner (Table 1).

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[1] Journal Series Paper No. 1673, approved by the Director of the Missouri Agricultural Experiment Station.

[2] Plant Pathologist, Department of Horticulture.

FIGURE 1. Close-up of Virginia Crab trunk topworked with "clean" Golden Delicious A.

FIGURE 2. Close-up of Virginia Crab trunk topworked with "pitted" Golden Delicious B and showing bark symptoms of stem pitting infection.

FIGURE 3. Stem pitting transmissions from Golden Delicious. From left to right, two Virginia Crab A inoculated with "clean" Golden Delicious A. Center, uninoculated Virginia Crab A. Right, two Virginia Crab A inoculated with pitted Golden Delicious B.

FIGURE 4. Close-up of two Virginia Crab A. Test tree on the left was inoculated with Golden Delicious A. Test tree on the right was inoculated with Golden Delicious B.

FIGURE 5. Transmission of stem pitting from Winesap. Test tree on left inoculated with Winesap W. Test tree on right inoculated with Winesap S.

Without exception, the Virginia Crab trees inoculated with the pitted budwood from Golden Delicious B and Early Harvest showed moderate to heavy pitting, indicating that the causal agent of the wood pitting in the bud parent tree had been transmitted. Virginia Crab budded with buds from the non-pitted Golden Delicious remained smooth and unpitted. One unbudded Virginia Crab control tree showed mild pitting which could have resulted from root grafting.

The results of the 1955-1956 test are listed in Table 2.

Virginia Crab test trees inoculated with the Golden Delicious A buds again remained smooth and free from the pitting disorder. Similarly, test trees inoculated with buds from Winesap S were smooth, indicating that this Winesap clone was free from infection. On the other hand, trees inoculated with Golden Delicious B showed the pitting observed the previous year. Similarly, pitting was found on all of the test trees inoculated with Winesap W buds, indicating that this clone was infected. Unbudded control Virginia Crab A remained smooth and free from pitting while the Virginia Crab B showed pitting similar to that observed on Golden Delicious B.

As an additional confirmation, small pieces of bark from pitted Virginia Crab inoculated with diseased Early Harvest buds were inserted beneath the bark of three trees of Virginia Crab A in 1955. In 1956 every tree showed pitting similar to the Early Harvest-inoculated trees in 1955.

In 1955, the test was repeated, using Golden Delicous Lot A, Golden Delicious Lot B, a vigorous strain of Winesap (S), and a weak-growing, late-blooming strain of Winesap (W), as budwood sources. Trees of Virginia Crab from Lot B (pitted) were also propagated and two were included in the readings (Table 2).

Experimental Results

The results of the 1954-1955 test are listed in Table 1.

Table 1. Results of transmission studies on apple stem-pitting involving pitted and non-pitted Golden Delicious and pitted Early Harvest apple trees, 1955.

Stock	Bud source (inoculum)	Total No. of trees	No. of trees inoculated	No. of trees pitted
Virginia Crab A	Golden Delicious A (not pitted)	2	2	0
"	Golden Delicious B (pitted)	4	4	4
"	Early Harvest (pitted)	3	3	3
"	Unbudded controls (not pitted)	3	0	1

Table 2. Results of transmission studies on apple stem pitting, involving pitted and non-pitted Golden Delicious and Winesap apple trees, 1956.

Stock	Bud source (inoculum)	Total No. of trees	No. of trees inoculated	No. of trees pitted
Virginia Crab A	Golden Delicious A	6	6	6
"	Golden Delicious B	4	4	4
"	Winesap S	5	5	0
"	Winesap W	5	5	5
"	Unbudded controls	6	0	0
Virginia Crab B	Unbudded	2	0	2

Discussion

A 3-year study indicated that the incompatibility troubles associated with certain Virginia Crab/variety combinations may be due in part or solely to virus infection. The causal entity produces a severe cracking in the bark and pitting of the wood on the trunk stem piece of a sensitive variety whenever it is top-worked or inoculated with an infected variety.

Wood pitting of Virginia Crab trunks top-worked to commercial varieties appears to be widespread in many fruit growing sections of the United States and Canada. In many cases, the resultant double-worked trees are dwarfed only slightly and fruit production is excellent, both in quality and quantity. Most varieties on seedling roots appear to be little affected; if any, with the disease and grow quite normally, although this point has not been fully investigated.

The manner of spread in nature is not known, but the incubation period in Virginia Crab appears to require nearly an entire growing season. The possibility of seed transmission, until adequately investigated, cannot be excluded as a source of infection.

Summary

A disease manifested by a severe bark splitting and wood pitting on the Virginia Crab stem piece of double-worked apple has been shown to be experimentally reproduced in healthy trees by budding from infected trees, and therefore must be considered a virus disease. Most varieties appear to be resistant to this causal entity and until a better indicator is discovered by research workers, the variety Virginia Crab appears to be the most sensitive.

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MISSOURI AGRICULTURAL EXPERIMENT STATION, COLUMBIA

EXOCORTIS AND XYLOPOROSIS -- BUD-TRANSMISSION VIRUS DISEASES OF RANGPUR AND OTHER MANDARIN-LIME ROOTSTOCKS[1]

E. O. Olson and A. V. Shull

SUMMARY

A bark-shelling disease of mandarin-lime rootstocks in Texas, found to be bud-transmissible, has symptoms apparently identical with those described for exocortis virus infection of Rangpur mandarin-lime rootstock in Brazil. Because this disease occurred when tristeza and psorosis viruses were not present and xyloporosis (cachexia) sometimes occurred in its absence, the causal agent of bark shelling of mandarin-limes is probably exocortis virus and differs from the causal agents of tristeza, psorosis and xyloporosis. The varieties and strains found susceptible to exocortis are Citrus limonia Osbeck; Rangpur, Ling Mung, Poak Ling Mung, Red Ling Mung, and Kusaie mandarin-limes; and mandarin-lime CPB[2] introductions 7418, 10557, and 72901. Bark-shelling symptoms did not develop on Rough lemon rootstock. Comparison of unbudded mandarin-lime, sweet lime, tangelo, Mexican lime, and Morton citrange seedlings with grapefruit on the same rootstocks budded from source trees with and without various disease symptoms warranted these conclusions. In another test the virus causing exocortis of Red Ling Mung mandarin-lime rootstocks occurred in 5 of 8 red grapefruit bud-source trees, 1 of 4 Valencia orange bud-source trees, and in both of the 2 Jaffa orange bud-source trees tested; seedling Red Blush grapefruit trees, nucellar Valencia orange, and nucellar Ruby blood orange trees were free of the virus.

INTRODUCTION

Grapefruit trees grown on Rangpur mandarin-lime rootstocks are more salt-tolerant than those grown on Rough lemon or sour orange rootstocks. Trees on Rangpur rootstock also have good lime tolerance, good cold tolerance, and moderate tolerance to excess boron in irrigation water (5). The Rangpur mandarin-lime rootstock is used commercially in Brazil, where its tristeza tolerance is important (7).

The use of Rangpur mandarin-lime rootstock however, is limited by its susceptibility to "Rangpur lime disease", common in rootstock plantings with red grapefruit and sweet orange tops in the Lower Rio Grande Valley. In affected trees, the rootstock bark splits, gums and later shells off; affected trees show a girdling response: vein-yellowing and off-season flowering (8). These symptoms also occur on other varieties of the mandarin-lime group, described by Webber (14).

By 1952 it seemed possible that the cause of the "Rangpur lime disease" might be a bud-transmitted virus, possibly identical with one of four suspects: psorosis (6), cachexia (3, 8), xyloporosis (12), and exocortis (1, 2). The original objective of this study was to investigate this possibility.

After this experiment was initiated in 1952, published evidence from Brazil indicated that bark-shelling of Rangpur rootstocks is caused by a bud-transmitted virus, exocortis (7). On the basis of Moreira's evidence from Brazil, the term exocortis is used hereafter in this paper to designate the bark-shelling symptoms of "Rangpur lime disease" in mandarin-lime varieties, as well as those in Poncirus trifoliata and its hybrids, its more customary use (1). This usage implies that the two diseases have the same causal agent, although it is the senior writer's opinion that more definite proof of this is necessary.

By 1954, it became evident that grapefruit buds from trees with exocortis symptoms on Rangpur rootstock would transmit cachexia symptoms to Orlando tangelo test plants (11); some Rangpur rootstock plants also showed symptoms characteristic of cachexia (9). These

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[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the United States Department of Agriculture. Photographs were taken by Bailey Sleeth, Texas Agricultural Experiment Station.

[2] Office of Crop Physiology and Breeding Investigations, former Bureau of Plant Industry, United States Department of Agriculture.

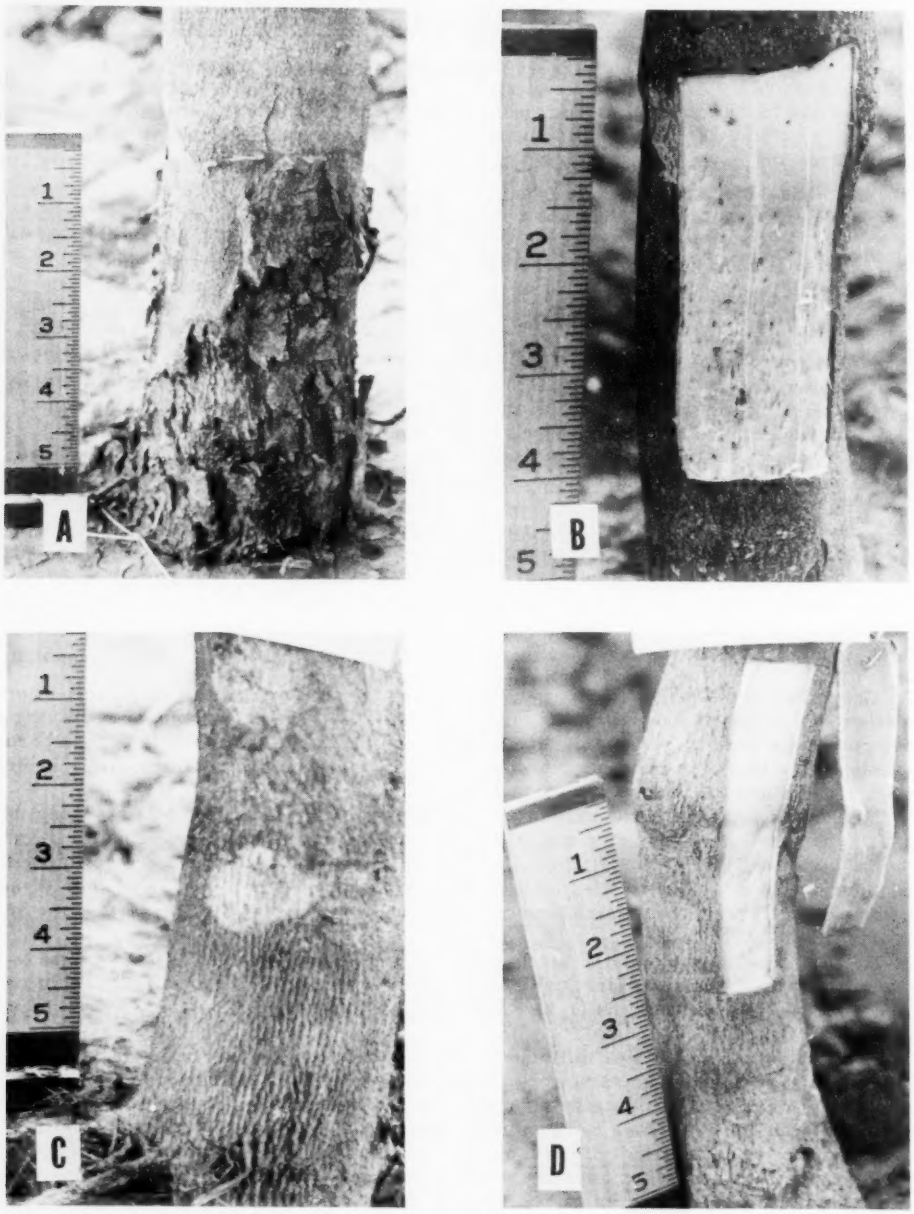

FIGURE 1. A and B -- Rangpur mandarin-lime rootstock, 44 months after insertion of buds from a psorosis-free Red Blush grapefruit tree, showing symptoms of (A) exocortis and (B) xyloporosis. C -- Rangpur mandarin-lime rootstock, 44 months after insertion of buds from a Marsh white grapefruit with xyloporosis but without exocortis on Rangpur rootstock, showing absence of exocortis symptoms. D -- Butwal sweet lime rootstock handled the same as C, showing symptoms of xyloporosis.

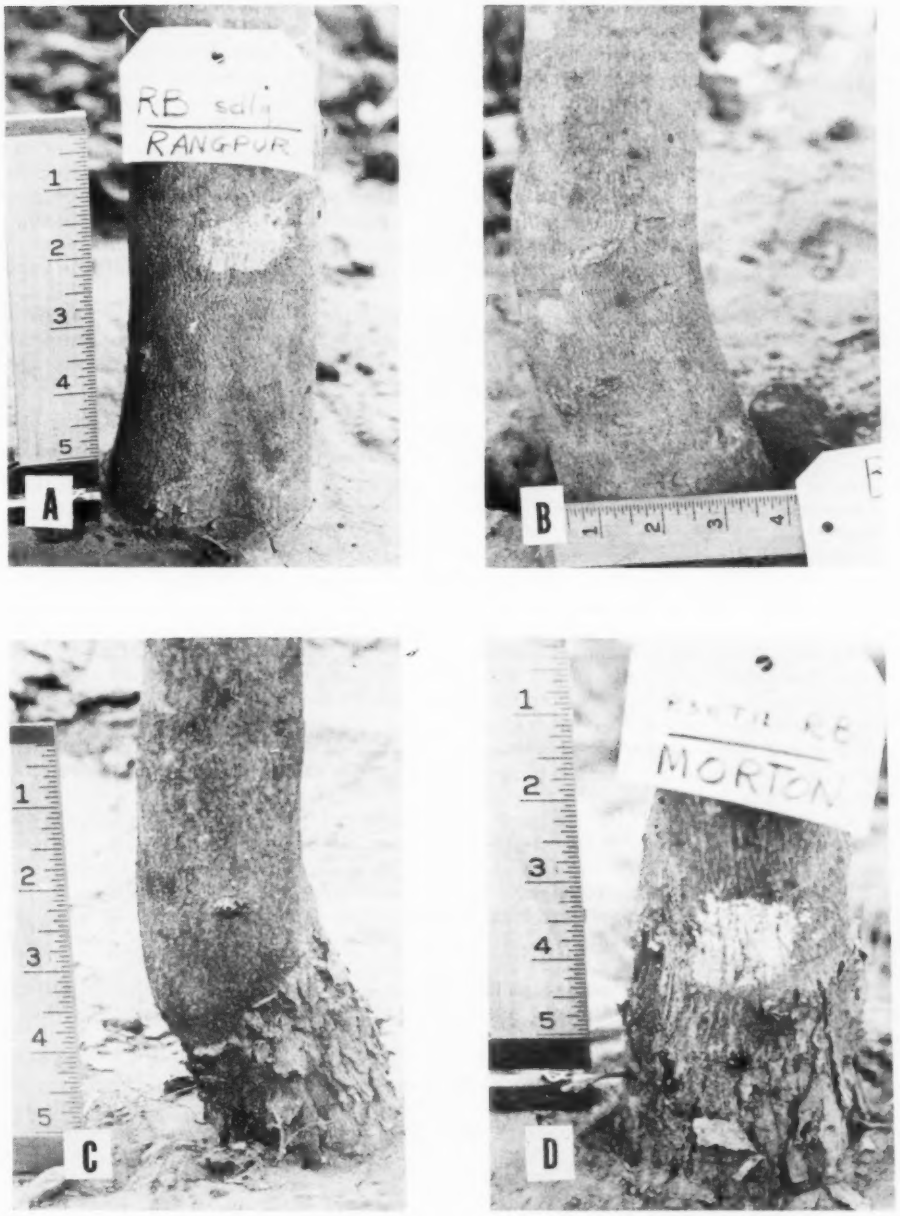

FIGURE 2. A and B -- Mandarin-lime rootstocks without exocortis symptoms 44 months after insertion of grapefruit buds: A, Rangpur rootstock budded with 1-year-old Red Blush seedling buds; B, Red Ling Mung rootstock budded with Ballard red grapefruit buds. C -- Red Ling Mung rootstock, 44 months after insertion of buds from Shary Red grapefruit, showing symptoms of exocortis. D -- Morton citrange rootstock showing symptoms of exocortis 44 months after insertion of buds from a Red Blush grapefruit tree with exocortis on its Rangpur mandarin-lime rootstock.

observations led to an increased interest in the relation of exocortis to cachexia.

Childs (3, 4) considered cachexia, a bud-transmitted disorder of mandarin and mandarin-hybrid rootstocks, to be identical with xyloporosis, a disorder of sweet lime rootstocks in Palestine (12). Both cachexia and xyloporosis are characterized by gum-stained inner bark and by pegs which project from the inner bark and fit into pits in the wood. The phloem discoloration symptom, which is very pronounced in cachexia-infected Orlando tangelo trees, is either not present or is much less marked in sweet limes infected with xyloporosis (4). Childs (4) reported seed-transmission of xyloporosis in 20 of 30 sweet lime seedlings and bud-transmission of xyloporosis in 5 of 5 sweet lime seedlings budded with tissue from cachexia-infected Orlando tangelo trees. The term xyloporosis is used in Florida as a synonym for cachexia; this practice is followed hereafter in this paper. This usage implies that the two diseases have the same causal agent, although it is the senior writer's opinion that more definite proof of this is necessary.

This report presents additional evidence that bark-shelling of Rangpur is caused by exocortis virus, extends the list of mandarin-lime varieties and strains susceptible to exocortis virus, and presents evidence that xyloporosis is a bud-transmitted disease with a causal agent differing from that of exocortis, psorosis, and tristeza.

METHODS AND MATERIALS

To determine whether a bud-transmitted virus caused exocortis of mandarin-limes in Texas, we compared unbudded mandarin-lime seedlings with budded trees on the same rootstock. To determine the relation, if any, of the exocortis disorder of mandarin-limes to other known bud-transmitted diseases, we propagated the bud-source trees listed in Table 1 on other virus-indicator rootstocks: sweet limes for xyloporosis, Orlando or Sunshine tangelo for xyloporosis (cachexia), Morton citrange for exocortis, and Mexican lime for tristeza. Rough lemon also was included in the test because of its commercial importance in Florida and because it shows some similarities to the mandarin-limes. Citrus limonia Osbeck was included because the Rangpur and Kusaie mandarin-limes are sometimes classed as varieties of this species (13).

In another experiment, buds were taken from individual psorosis-free trees of different red grapefruit strains and from individual trees of Jaffa, Valencia, and Ruby sweet oranges (Table 2). These buds were grafted to seedlings of Red Ling Mung mandarin-lime and trees were propagated to determine whether the progeny of these bud-source trees would develop bark-shelling symptoms on the rootstock.

Budding was done in August 1952. In the fall of 1953 the test plants on Rough lemon, sweet lime, Mexican lime, five mandarin-lime varieties, Morton citrange, most tangelos, and the test plants listed in Table 2 were set out at a 14 x 5 foot spacing. In the nursery rows of six mandarin-lime varieties and strains (Rangpur, Poak Ling Mung, Red Ling Mung, Kusaie, CPB 7418, and CPB 10557), the test plants were thinned to four plants per treatment, the same as for transplanted trees, and left in place with 14 feet between rows and a spacing of 2 to 8 feet between trees.

All trees on an individual roostock except the tangelo test plants and some Morton citrange trees were in a single row. The treatments were randomized in the transplanted trees, but not in those left in the nursery row.

The test trees, grown at Rio Farms, Inc., Edcouch, Texas, were observed for psorosis symptoms in the foliage; for development of bark-shelling symptoms of exocortis; for symptoms of xyloporosis, characterized by gum stain in the inner bark and pitting and pegging of the wood and inner bark of the rootstock. Final readings of disease symptoms were made in May 1956.

RESULTS

Bud-transmission of Exocortis Symptoms to Budded Rootstocks

Exocortis symptoms developed on the mandarin-lime rootstocks of trees with Red Blush or Shary Red grapefruit tops and on the Morton citrange rootstocks of trees with Red Blush tops, but not on unbudded mandarin-lime or Morton citrange seedlings and not on the mandarin-lime or Morton citrange rootstocks of trees with 1-year-old seedling Red Blush grapefruit tops (Table 1). These results indicate that exocortis is caused by a bud-transmitted virus present in some grapefruit trees.

Varieties and strains susceptible to exocortis virus are C. limonia Osbeck; Rangpur, Ling Mung, Poak Ling Mung, Red Ling Mung, and Kusaie mandarin-limes; and mandarin-lime CPB

Table 1. Prevalence of symptoms of virus diseases on unbudded citrus rootstocks and on rootstocks budded 44 months previously with buds from various grapefruit sources.

Source of grapefruit buds	Source rootstock or seedling	Kind of disease symptoms on bud-source rootstock	Rootstocks budded	Test	Number of plants With indicated symptoms on rootstocks: Exocortis	Xyloporosis	Viruses in bud-source or seedling
None (unbudded check seedling)	----	----	Mandarin-limes[a]	44	0	0	None
			Sweet limes[b]	4	0	0	
			Tangelos[c]	3	0	0	
			Rough lemon	4	0	0	
			Morton citrange[d]	7	0	0	
1-year-old Red Blush seedlings	----	----	Mandarin-limes	44	0	0	None
			Sweet limes	4	0	0	
			Tangelos	10	0	0	
			Rough lemon	4	0	0	
			Morton citrange	3	0	0	
Marsh white (tree 28-5 planted in 1947)	Rangpur mandarin-lime	Xyloporosis only	Mandarin-limes	44	0	7	Xyloporosis only
			Sweet limes	3	0	3	
			Tangelos	3	0	2	
			Rough lemon	4	0	0	
			Morton citrange	2	0	0	
Red Blush (tree 30-12, planted in 1947)	Rangpur mandarin-lime	Exocortis only	Mandarin-limes	44	40	7	Xyloporosis and exocortis
			Sweet limes	3	0	3	
			Tangelos	3	0	1	
			Rough lemon	3	0	0	
			Morton citrange	2	2	0	
Shary Red (tree 61-3 planted in 1950)	Cunningham citrange	Exocortis only	Mandarin-limes	40	33	3	Xyloporosis and exocortis
			Sweet limes	4	0	3	
			Rough lemon	4	0	0	
Red Blush (tree 2B-3, planted in 1942)	Sour orange	None (tree registered as psorosis-free)	Mandarin-limes	44	40	5	Xyloporosis and exocortis
			Sweet limes	4	0	3	
			Tangelos	1	0	1	
			Rough lemon	4	0	0	

[a] Eleven varieties and strains (2 strains of C. limonia Osbeck; 2 strains of Rangpur, Ling Mung, Poak Ling Mung, Red Ling Mung, Kusaie, and the following CPB introductions: 7418, 10557, and 72901) were used.
[b] Sweet lime varieties were Butwal and Columbian. [c] Tangelo varieties were Orlando and Sunshine. [d] Located at Harold Randle farm, Mission.

Table 2. Prevalence of exocortis symptoms on Red Ling Mung mandarin-lime rootstocks budded 44 months previously with red grapefruit and sweet orange buds.

Bud-source tree, variety or strain	Bud-source tree, location[a]	Budded trees in each test	Budded test trees with exocortis
Red grapefruit:			
Red Blush seedlings	-----	2	0
Ballard	ST 3-11	3	0
Fawcett	ST 1-2	3	0
Henninger	ST 1-9	3	0
Curry Red Radiance	ST 1-5	3	2
Goodwin	ST 1-10	3	3
Red Blush	ST 1-14	3	3
Riddle Red Gold	ST 1-4	3	3
Shary Red	ST 1-6	3	3
Sweet oranges:			
Nucellar Valencia	DG 5-12	12	0
Nucellar Ruby blood	DG 14-7	5	0
Valencia	RG 1-19	2	0
Valencia	RF 2-20	2	0
Valencia	RF 4-16	2	0
Valencia	RF 8-21	2	2
Jaffa	RF 29-17	2	2
Jaffa	TAES	2	2

[a] ST, trees from a red grapefruit strain test, Substation 15, Texas Agricultural Experiment Station, Weslaco. DG, trees interplanted in a date garden, Substation 15. RF, trees grown in a grove at Rio Farms, Inc., Edcouch. TAES, isolated tree on grounds at Substation 15.

introductions 7418, 10557, and 72901. Rough lemon rootstock did not show barkshelling symptoms.

First symptoms of bark-shelling on mandarin-lime rootstocks were noted in November 1954, approximately 2 years after budding, in trees left in place in the nursery row. First symptoms in transplanted trees developed a year later.

The symptoms generally followed a specific pattern. Small gumming pustules formed at approximately the soil level or higher on the trunk. Gum exuded from the pustules and the outer bark began to shell off (Fig. 1 A). On some trees new bark formed beneath the shelled bark; on others the bark was killed to the wood. As the severity of bark-shelling increased, the growth rate of the plant slowed down, the foliage showed some chlorosis, and off-season flowering occurred. These symptoms are apparently identical with those reported for exocortis of Rangpur rootstock in Brazil by Moreira (7), who considered the disease identical with the "Rangpur lime disease" reported in Texas (8). The symptoms of exocortis of mandarin-limes are also similar to exocortis symptoms on Morton citrange in Texas, and to symptoms of exocortis on California-grown rootstocks of Poncirus trifoliata and Cunningham and Morton citranges (2).

Bud-transmission of Xyloporosis Symptoms to Budded Rootstocks

Xyloporosis symptoms developed on the tangelo and sweet lime rootstocks of trees with Red Blush, Shary Red, and Marsh white grapefruit tops, but not on unbudded sweet lime or tangelo seedlings. Symptoms did not occur on sweet lime or tangelo rootstocks of trees with 1-year-old seedling red grapefruit tops (Table 1). These results confirm previous tests (10) showing that xyloporosis of tangelos (cachexia) is caused by a bud-transmitted virus present in some grapefruit trees. These results are also evidence that xyloporosis of sweet lime

rootstocks is caused by a bud-transmitted virus also present in some grapefruit trees, but not in the seedlings tested.

Xyloporosis symptoms were also noted in some budded trees on mandarin-lime rootstocks (Fig. 1 B; Table 1) and were more common in trees left in place in the nursery row. Xyloporosis symptoms were noted on Rangpur, Poak Ling Mung, Red Ling Mung, Kusaie, and CPB 7418 mandarin-lime rootstocks of trees with grapefruit tops. Symptoms were especially common on the Kusaie mandarin-lime rootstocks; 11 of 16 trees with grapefruit tops showed xyloporosis symptoms; 6 showed symptoms of both xyloporosis and exocortis. It seems probable that transplanting delayed the development of xyloporosis symptoms in the rows of transplanted, inoculated and susceptible mandarin-lime rootstocks. Xyloporosis symptoms are expected to develop in additional trees in the future, especially in trees with Marsh White grapefruit tops; in these trees exocortis does not interfere with the expression of xyloporosis symptoms on the rootstock.

Virus Status of Bud-Source Trees, as Indicated by Behavior of Their Budded Progeny on Indicator Rootstocks

As shown in Table 1, trees with no visible evidence of virus diseases included the unbudded rootstock seedlings and those with Red Blush grapefruit seedling tops (Fig. 2A). The causal agent of xyloporosis, but not that of exocortis, was carried by a Marsh white grapefruit tree (Fig. 1 C, D). This indicates that the causal agents of the two diseases are different. The causal agents of xyloporosis and exocortis (Fig. 2 C, D) were carried by two Red Blush grapefruit trees and a Shary Red Grapefruit tree.

As shown in Table 2, year-old Red Blush grapefruit seedlings, 3 red grapefruit trees (including the one shown in Fig. 2B), 3 Valencia orange trees, a nucellar Valencia orange, and a nucellar Ruby blood orange did not carry the causal agent of exocortis. Five red grapefruit trees, 2 Jaffa orange trees and a Valencia orange tree carried the causal agent of exocortis.

Absence of Psorosis and Tristeza Viruses in Bud-Source Trees and Their Progeny

No psorosis leaf symptoms were observed in the test plants, although psorosis leaf symptoms were constantly detected in the progeny of known psorosis-infected trees growing in adjacent experiments. The red grapefruit bud-source trees listed in Table 2 are the progeny of trees registered by the Texas Department of Agriculture as psorosis-free. Except for one tree (RF 8-21), the Valencia orange trees are also registered as psorosis-free. The Jaffa orange from Rio Farms is also registered, but the TAES Jaffa orange is not. Since psorosis virus is rarely if ever seed-transmitted, the nucellar trees and seedlings are considered psorosis-free.

The progeny of the bud-source trees grew well on sour orange rootstock in an adjacent experiment, and Mexican lime seedlings inoculated with buds from these sources showed no symptoms of tristeza infection in screenhouse and field studies. At present, tristeza infection is either unknown or rare in grapefruit and sweet orange trees in Texas, but the virus does occur in some Meyer lemon trees (10). It therefore seems unlikely that tristeza virus was present in the test plants in this experiment.

DISCUSSION

Childs (3, 4) considered cachexia virus identical with that causing xyloporosis. Moreira (7) reported that exocortis virus was identical with that causing bark-shelling of the Rangpur rootstock. The results of the present experiment in Texas present additional evidence in agreement with the respective hypotheses of Childs and Moreira, and indicate that the causal agent of xyloporosis is different from that of exocortis.

If the causal agent of bark-shelling of mandarin-limes is exocortis virus, the Rangpur is a better indicator plant for this virus than Poncirus trifoliata, which grows slowly in Texas. The comparatively rapid growth of budded trees on Rangpur rootstock, even in saline or calcareous soils, combined with easy detection of bark-shelling symptoms, may provide a faster method of detecting exocortis infection in bud-source trees than is possible with P. trifoliata as an indicator plant. The observed occurrence of xyloporosis symptoms in the mandarin-lime rootstocks of some trees left in the nursery row suggests that test trees free from exocortis may reveal the xyloporosis status of the bud-source tree. However, bark-shelling from exocortis may in-

terfere with the expression of xyloporosis symptoms, particularly on trees budded low on the rootstock. Some mandarin-lime test plants, budded about 1 foot above the soil level, have shown symptoms of two diseases: exocortis developing near the soil line, and xyloporosis just below the bud union. Likewise, xyloporosis infection may interfere with the expression of exocortis symptoms. For positive evidence as to the virus status of bud-source trees, varieties sensitive to only one virus may be preferable.

The data in Table 2 indicate that many psorosis- and tristeza-free trees in Texas carry the causal agent of exocortis. Previous work (11) showed that individual trees of seven red grapefruit strains carried the causal agent of xyloporosis when tested on Orlando tangelo.

Since red grapefruit seedlings are free from these viruses, they can provide virus-free scions necessary to utilize virus-sensitive rootstocks of promise for Texas conditions. It remains to be seen whether these red grapefruit seedling trees on sour orange or experimental rootstocks will be more productive than present strains of red grapefruit on sour orange rootstock, the standard rootstock in Texas at present.

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INCREASED RUNNER PRODUCTION AND FRUIT YIELD OF VIRUS-FREE STRAWBERRY PLANTS OVER COMMERCIAL STOCKS IN NEW HAMPSHIRE[1, 2]

Robert F. Becker and Avery E. Rich[3]

Summary

During the 1954 and 1955 growing seasons a comparison was made between virus-free and locally grown commercial strawberry plants with reference to plant production and fruit yield. The average numbers of runner plants produced per mother plant in 1954 for the virus-free Catskill, Premier, and Sparkle were 89, 160, and 95, respectively, and for the commercial plants 39, 93, and 81. Yield data were taken in 1955. The average yields per clone for the virus-free Catskill, Premier, and Sparkle were 10.6, 13.5, and 10.9 quarts, respectively, as compared to 3.9, 8.0, and 7.2 quarts for the locally grown commercial plants. The greater fruit yield of the virus-free clones of each variety seemed to be due more to a larger number of plants produced in these clones than to more or larger berries per plant.

Numerous studies pertaining to strawberry viruses and associated problems have been made during the last 25 years by various workers. In a recent article, Plakidas (7) reviewed the literature on the strawberry virus situation. Although it is generally agreed that viruses of the yellows-crinkle complex reduce plant vigor, thereby decreasing fruit yield and potential runner plant production, most available information as to the extent of such damage is only estimative (3, 4, 5, 6).

In a recent study carried on in the Hudson River Valley, Braun (1) showed that virus-free plants of the varieties Catskill, Premier, and Sparkle were superior in runner production to non-virus-free commercial plants.

Zeller (8), working with crinkle, found that in Oregon healthy Marshall plants produced 7136 pounds of fruit per acre, compared to 3402 pounds for virus-infected plants. During the 1953 and 1954 growing seasons, Braun (1, 2) carried on studies to determine the effects of viruses and nematodes on strawberry plants. His study showed that virus-free plants of the Catskill, Premier, and Sparkle varieties yielded 6359, 7378, and 5764 quarts per acre, respectively, as compared to 4762, 649, and 604 quarts per acre for the non-virus-free plants.

To obtain more information on the effects of strawberry viruses on plant production and fruit yield, a comparison was made between virus-free and locally grown commercial strawberry plants.

Materials and Methods

Virus-free plants of the varieties, Catskill, Premier, and Sparkle were obtained in early March, 1954 from the Plant Industry Station at Beltsville, Maryland. In order to multiply these virus-free stocks and at the same time eliminate any possible red stele infection (*Phytophthora fragariae*) or nematode contamination, during April and May, virus-free runner plants were rooted in flats of steam-sterilized soil. The commercial plants were obtained shortly before planting time from local nurserymen who had maintained their own stock.

The planting site was chosen because it was comparatively isolated from other strawberry plants, being over 1/4 mile away from any commercial plants and at least 200 feet from wild species. Only green manure crops had been grown on this land since its conversion from

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[1] Published with the approval of the Director of the New Hampshire Agricultural Experiment Station as Scientific Contribution No. 190.

[2] Based on a portion of a thesis submitted by the senior author to the Graduate School of the University of New Hampshire in partial fulfillment of the requirements for the degree of Master of Science, May 1956.

[3] Research Assistant and Plant Pathologist, respectively, New Hampshire Agricultural Experiment Station.

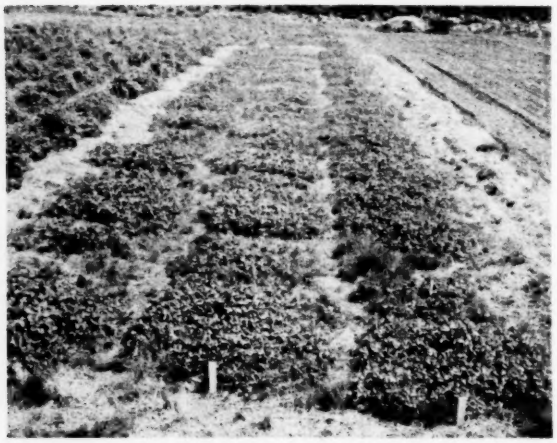

FIGURE 1. Comparison of relative size of virus-free and commercial strawberry clones (alternating from front to back in each row). Catskill, left; Premier, center; and Sparkle, right.

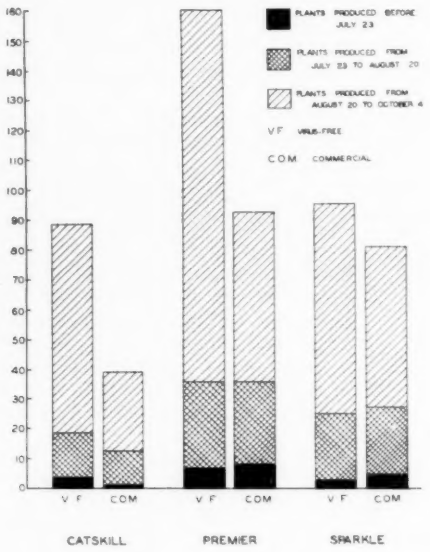

FIGURE 2. The average number of runner plants per mother plant on three counting dates during the 1954 growing

forest to tillable land in 1951. The soil is classified as Charlton stony loam.

On May 28, the plants were set in three rows, one row per variety. Ten virus-free plants were paired with 10 commercial plants in each row. In order to keep each clone separate a space of 7 feet was allowed between the rows, and the plants were set 5 feet apart in the rows. Thus, each plant was placed in the center of a 35-square-foot area. Periodically during the summer the newly formed runner plants were spaced so as to form clones in the area around each mother plant. No runners were removed.

Throughout the season, 4% malathion dust was used to control aphids and consequently prevent virus spread and infection of the virus-free plants. Applications were made every week to 10 days from planting time until late fall; this practice was renewed the following spring and continued until within 3 weeks of harvest.

To determine the differences in plant production between virus-free and commercial plants, the number of runner plants produced by each mother plant were counted on July 23, August 20, and October 4. Only plants with one or more open true leaves were counted.

Since it was felt that Botrytis fruit rot (Botrytis cinerea Pers.) might become a problem, especially if the harvest season proved to be rainy, 7.5% captan dust was applied to reduce losses from this disease. Applications were made on May 31, June 9, and June 16.

During the harvest season, which lasted from June 13 to July 9, the berries were usually picked every 2 days. All the fruit from each clone was picked and the yields were recorded in terms of quarts. All the berries remaining on the plants were picked at the end of the harvest period (July 5 for the Premier variety, July 7 for Catskill, and July 9 for Sparkle).

A survey was conducted after harvest to determine whether nematodes were present in any of the clones. Parasitic meadow nematodes, Pratylenchus penetrans (Cobb.) Sher. & Allen, were recovered from three clones (Catskill clones 4 and 10 and Premier clone number 18) of the commercial plants. Since the object of this study was to show the effect of viruses on strawberry plant production and fruit yield, no data from these three nematode-infected clones or their virus-free counterparts are included in any of the following results.

Experimental Results

The summer of 1954, being relatively cool and moist, was ideal for strawberry plant production. Young runners rooted easily in the moist soil and quickly developed into full-grown

Table 1. Number of strawberry runner plants constituting each clone on 3 dates during the growing season of 1954.

Clone Number	Catskill 7/23	Catskill 8/20	Catskill 10/4	Premier 7/23	Premier 8/20	Premier 10/4	Sparkle 7/23	Sparkle 8/20	Sparkle 10/4
#1	5	31	144	8	48	173	5	33	123
2	1	9	38	7	32	70	3	16	33
#3				7	27	149	3	25	103
4				9	36	83	5	31	96
#5	7	31	141	5	39	196	2	25	121
6	1	7	27	9	37	86	3	23	85
#7	1	16	75	9	46	203	3	31	107
8	0	4	23	6	25	70	6	28	82
#9				3	20	73	4	32	123
10				11	53	168	5	22	67
#11	7	21	98	8	51	198	2	28	66
12	1	21	84	6	26	60	4	21	41
#13	4	11	78	10	40	177	3	15	70
14	1	8	27	10	38	117	3	21	69
#15	5	22	91	5	21	118	4	23	101
16	2	19	42	7	29	53	4	37	96
#17	0	4	29				2	13	70
18	3	15	38				7	31	102
#19	1	10	53	5	32	157	2	18	70
20	1	13	35	9	48	128	10	41	140
Average virus-free	3.8	18.3	88.6*	6.7	36.0	160.4*	3.0	24.3	95.4
Average Commercial	1.3	13.3	39.3	8.2	36.0	92.8	5.0	27.1	81.1

* Significant at 19:1
\# Virus-free clones

plants. By the beginning of August, differences in the size of clones were beginning to become apparent. As the season progressed, visual observations indicated that there were marked differences in certain cases. Figure 1 illustrates the variation in clonal size on October 1, 1954.

Table 1 shows the total number of runner plants in each clone on July 23, August 20, and October 4. By comparing the virus-free and commercial totals for each variety, it can readily be seen that the virus-free clones produced more runner plants than did the commercial clones. The average numbers of runner plants per mother plant for the virus-free Catskill, Premier, and Sparkle varieties were 88.6, 160.4, and 95.4, respectively, compared to 39.3, 92.8, and 81.1 runner plants for the commercial plants. By analysis of variance, it was found that the differences in runner production for the Catskill and Premier varieties were significant at the 5 percent level. There was no significant difference in runner production for the Sparkle variety.

The average number of runner plants per mother plant on July 23, August 20, and October 4 is shown in Figure 2. This graph shows that the virus-free Catskill mother plants consistently produced more runners than did the commercial Catskill plants. On the other hand, the differences in the Premier variety did not become apparent until sometime in September. Although the virus-free Sparkle mother plants finally produced more runners than did their commercial counterparts, in the initial stages of production the commercial plants led the virus-free plants in runner production.

The virus-free plants of all three varieties appeared more vigorous than the commercial stock, regardless of their clonal size. The virus-free clone seemed more thrifty, and the leaves were larger. There seemed to be some yellowing of the leaf margins of the commercial plants. This was especially noticeable with plants of the Catskill variety.

Table 2. Total quarts of berries per clone of virus-free and commercial Catskill, Premier, and Sparkle strawberries in 1955.

Clone Number	Catskill	Premier	Sparkle
#1	13.6	13.7	13.3
2	4.4	6.6	2.7
#3		14.2	10.9
4		6.9	8.7
#5	15.8	16.2	11.7
6	2.2	8.5	7.4
#7	11.7	15.7	11.7
8	1.9	7.6	8.1
#9		9.4	12.8
10		10.6	6.6
#11	11.8	16.4	9.4
12	6.5	6.4	2.3
#13	9.3	13.8	8.4
14	2.9	9.1	5.9
#15	11.2	9.5	11.8
16	5.4	6.5	9.8
#17	4.0		9.3
18	3.7		10.1
#19	7.5	12.5	9.2
20	3.8	9.4	10.7
Average virus-free	10.6**	13.5**	10.9**
Average commercial	3.9	8.0	7.2

** Significant at 99:1
# Virus-free clones

During most of the harvest season there was sufficient moisture and sunlight for fruit production[4]. The total number of quarts of fruit picked from each clone is shown in Table 2. The average yields per clone for the virus-free Catskill, Premier, and Sparkle were 10.6, 13.5 and 10.9 quarts, respectively, as compared to 3.9, 8.0, and 7.2 quarts for the commercial clones. Thus, on the average, the virus-free clones of the three varieties were more productive than were the commercial clones. After these yield data were analyzed by analysis of variance, it was found that all three varieties showed significant differences at the one percent level, in favor of the virus-free plants.

Discussion and Conclusions

Due to lack of runner formation in the greenhouse, no indexing was performed to determine whether the locally grown commercial plants were infected with virus. However, since it is generally agreed that most commercial stocks in the United States are infected with virus, it is probably safe to assume that most, if not all, of the commercial plants used in this study were infected.

Data obtained in the study indicate that the greater yields of the virus-free clones of Catskill and Premier were due to the larger number of runner plants produced by these clones rather than to a greater number of quarts per plant or larger berries. The increased yield in the Sparkle variety was due partly to the increased number of plants and partly to the greater number of berries per plant.

From the results of this study it would seem that, at least under the experimental conditions used, the chief value of the virus-free plants lies in their ability to produce abundant runner plants. Whether different results would have been obtained if each plant had been given

[4] 2.07 inches of rain in May; 4.96 in June.

more space can not be determined without further work. Since virus-free plants produce runners in profusion, it is probably safe to assume that virus-free mother plants must be set farther apart than non-virus-free plants before maximum benefit can be derived from virus-free stock. Some thinning of plants within the row may also be necessary.

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NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION, DURHAM

AN OUTBREAK OF EUROPEAN CANKER IN CALIFORNIA

Carl W. Nichols and E. E. Wilson[1]

Abstract

An outbreak of European canker disease, caused by Nectria galligena, has caused considerable damage to apple trees in Sonoma County, California, during the past two years. In one orchard several young trees and numerous small branches on bearing trees have been killed. No fruit infection has occurred. In winter the fungus produces abundant conidia on infected branches. Perithecia are initiated, but few mature under Sonoma County conditions. Infection of the leaf-scar areas of shoots occurs in early winter and the lesions become visible by early January. Bordeaux mixture 10: 10: 100, applied as a spray shortly after leaf-fall in the autumn, apparently reduced twig infection materially. The disease was not found in a limited survey of other important apple-producing counties.

Apple canker, or European canker, as it is known in this country, is an important disease in Europe. The disease, which is caused by the fungus Nectria galligena Bres. (1, 5, 7), has been found in North America from northeastern United States and southeastern Canada to the Pacific Coast. In Oregon it is said (8) sometimes to affect the pear more severely than the apple.

One of the earliest reports of European canker in California was made by Smith (4) in 1909. Smith noted the presence of the disease in the State but did not specify the localities in which it occurred. In 1912, however, Fawcett (3) identified it on apple specimens from Sonoma and Humboldt Counties, and in 1921 Dr. Elizabeth Smith sent Zeller and Owens (9) specimens of the disease on apple from Humboldt County. The Bureau of Plant Pathology, California Department of Agriculture received specimens of the disease from Humboldt County in 1946 and 1955 and from Del Norte County in 1950.

The three counties in which the European canker was found are situated on the coast north of San Francisco Bay in a region where winter rainfall is heavy and temperature is moderate throughout the year. Apparently, therefore, in California as elsewhere, the disease is most likely to occur in regions where the climate is mild and damp in winter.

In January 1955 our attention was called to a canker disease of apple trees in an orchard near Sebastopol, Sonoma County. Symptoms of the disease were similar in all respects to those described for European canker and a fungus isolated from the cankers produced conidia typical of the Cylindrocarpon stage of Nectria galligena. The creamy-white sporodochia of the same fungus were often present on affected twigs collected during rainy weather or on those held for a time in a moist chamber.

By March, small, red, ovate to spherical structures were found on cankers that were one or more years old. Some contained immature asci, but during the spring and summer of 1955 none were found with ascospores. Although repeated attempts were made to force these structures to maturity by placing them in a moist chamber, none succeeded. In the spring of 1956, however, after an extensive search, one perithecium was found with mature ascospores. The perithecium and the ascospores were similar to those described for Nectria galligena and colonies produced from the ascospores developed conidia similar in size and shape to those described for that fungus.

In a survey made in cooperation with the Agricultural Commissioner's Office and the Agricultural Extension Service of Sonoma County, the disease was found in seven other orchards in that county. In addition, one specimen was received by Dr. H. E. Thomas of the University of California at Berkeley from the neighboring county of Marin. A limited survey was made by the Bureau of Plant Pathology, California Department of Agriculture and the Agricultural Commisioner's Offices in the Sierra Nevada foothill apple-growing district of Butte County; in Mendocino County, which joins Sonoma County on the north; and in Monterey and

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[1] Associate Plant Pathologist at the California Department of Agriculture, Sacramento; and Plant Pathologist at the University of California at Davis, respectively.

Santa Cruz Counties, which lie on the coast south of San Francisco Bay. No other cases of the disease were found in this survey[2].

Apple varieties most commonly affected by European canker in Sonoma County are Gravenstein and the red sports of Delicious. The latter apparently are the more susceptible. Trees of the Golden Delicious, Jonathan, and Rome Beauty varieties growing in the same orchard with diseased Delicious were free of the disease.

Lesions that appeared during the winter were usually located at the nodes of twigs produced the previous growing season. In this type of infection, according to Wiltshire (6), leaf scars provide the avenues of entry for the fungus. Both in 1955 and 1956 such lesions had become visible by early January. While few if any new lesions developed in the spring of 1955, a few developed in the spring of 1956. These were commonly located at the base of the new growth, at places where no leaf scars occurred. Little if any infection of pruning wounds was found, a situation differing from that in Oregon (8).

At times, the fungus extended from infected spurs or side shoots back into the supporting branches and there produced cankers 2 to 4 inches long. It was on such cankers that the perithecia were initiated.

Fruit infection was not encountered though it is said to be common under European conditions. It is unlikely that this type of infection will become prevalent in Sonoma County, where rains are infrequent after the fruit is formed.

Judging from its behavior during the past two years, under our conditions the disease may do extensive damage to the twigs and branches of susceptible apple varieties. In one orchard it has killed several small trees and destroyed many twigs on mature trees. The fungus survives for several years in the branch cankers, where in winter it produces an adequate supply of conidia for new infection. Ascospores apparently play a minor role in infection.

Since most of the infection takes place through leaf scars the protection of these courts of entry with a fungicide has resulted in a marked reduction of the incidence of new infection (2, 8). Bordeaux mixture is the fungicide most commonly employed. We have, therefore, recommended that the trees be sprayed with Bordeaux mixture 10: 10: 100, in autumn as soon after leaf-fall as possible. In 1955 one grower followed this procedure. In addition he carefully removed the diseased twigs from the trees though he did not always remove the larger branches which bore cankers. In 1956, twig infection was comparatively rare in his trees, whereas it was abundant in trees of an adjoining unsprayed orchard.

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CALIFORNIA DEPARTMENT OF AGRICULTURE, SACRAMENTO; AND UNIVERSITY OF CALIFORNIA, DAVIS

[2] The writers wish to express their appreciation to Roy M. Nakayama, formerly Assistant Plant Pathologist and Dan Y. Rosenberg, Assistant Plant Pathologist of the California Department of Agriculture, for assistance in the survey.

SILVER-LEAF OF MONTMORENCY SOUR CHERRY IN OREGON

H. E. Williams and H. R. Cameron

Abstract

Silver-leaf of Montmorency sour cherry, caused by Stereum purpureum (Pers. ex.Fr.) Fr., has been found in Oregon. Native Oregon oak, Quercus garryana Dougl., was thought to be the normal host of the fungus and to have been the source of inoculum. Control measures have been tried, but warm summer temperatures appeared to retard the fungus and allow most trees to recover without additional treatment.

Silver-leaf incited by Stereum purpureum (Pers. ex Fr.) Fr. was first observed on plums in France in 1885 (13). Since then S. purpureum has been reported to incite symptoms on almond, apple, apricot, ash, cherry (wild and cultivated), chestnut, currant, gooseberry, nectarine, peach, quince, laburnum, lilac, poplar, silver birch, and willow (7, 11). Birch, beech, and rhododendron have been reported to be symptomless hosts (6).

Symptom expression is fairly uniform and consists of silvering of the foliage and discoloration of the wood in the area infected by the fungus. Percival, in 1902 (12), showed that the silveriness of the foliage is due to partial separation of the mesophyll cells from each other and the leaf epidermis. The abnormal air spaces produced by the separation affect the quality of reflected light so that the leaf surface appears silvery. The chloroplasts may become yellowish at a later stage and, in severely affected leaves, brown necrotic areas may develop before leaf fall. Brooks and Brenchley (2) induced silveriness in plum leaves by the introduction of a filtered extract of the fungus into the stems and showed that some product of metabolism of the fungus is responsible for leaf symptoms. The brown discoloration in the branches, trunk, or roots may vary from a small area to nearly the entire cross section and occurs in continuous streaks or zones from the center of infection but spreads more rapidly upward than downward. Brooks, et al., (1, 3, 4) have shown that a "gum barrier" may be formed around the invaded tissues. The gum barrier is formed by the host and consists of a narrow zone of gum that is darker in color and more densely aggregated than in the area invaded by the fungus. The gum barrier usually encloses the fungus, which then gradually dies, and may permit the affected trees to recover. Heald (10) states that infection with S. purpureum is almost invariably followed by the death of the branch or, if allowed to run its course, by the death of the entire tree. The rapidity of advance of the disease, however, appears to depend upon both internal and external factors and varies with different trees and in different locations.

In Oregon, S. purpureum has been present for at least 40 years, but has not been recognized in commercial orchards, and has never been reported to affect Montmorency sour cherries. In 1954, a block of 448 trees was surveyed. Sixty-three or 14 percent were showing silver-leaf symptoms. Since then Montmorency sour cherry trees infected with S. purpureum have been found in two additional orchards in widely separated areas of western Oregon.

On individual trees symptoms ranged from one small branch to the entire tree. Severely affected branches dropped their flowers or young fruit. Affected leaves had a silvery cast, were smaller in size than normal, and in some cases were slightly misshaped and somewhat bumpy (Fig. 1). The most severely affected leaves displayed varying amounts of necrosis which consisted of marginal burning or scattered necrotic spots. Terminal growth on affected branches was stunted, and a brownish discoloration in the xylem was always associated with those branches displaying silvered leaves. The discoloration was in the central core of the xylem (Fig. 2) and could be found only at some distance from the terminals. The discolored areas were brownish in color and darker at the advancing margin. The roots showed discolored areas near the trunk, but isolations from smaller healthy appearing root tissues yielded the same organism that was isolated from the discolored areas of branches[1].

Injury to the wood was observed in sections made with the sliding microtome and stained according to the process of Cartwright (5). Some xylem vessels and ray cells in the region of the advancing margin were plugged with either an amber colored, or a dark granular,

[1] Identification of the fungus was confirmed by Dr. Mildred K. Nobles, Senior Mycologist, Botany and Plant Pathology Laboratory, Ottawa, Canada.

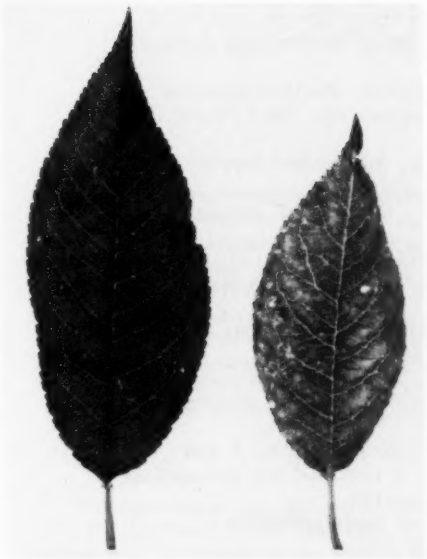

FIGURE 1. Montmorency sour cherry leaves. Healthy leaf at left. Leaf at right shows reduced size and silver cast of affected leaves.

FIGURE 2. Cross section of Montmorency sour cherry trunk just above graft union. Discoloration in xylem continues up the trunk and down into the crown.

material while those inside the advancing margin were, generally, free of the foreign material. Many ray parenchyma cells contained the dark granular material. Tyloses were associated with those vessels containing either the amber colored or dark granular material, and hyphae were observed in both vessels and fiber tracheids. Tissue sections stained with phloroglucinol showed that the amber colored material plugging vessels and ray cells was of the wound-gum type.

Observations made during 1955 and 1956 have indicated that many infected trees have recovered. Some trees still show symptoms but have made sufficient recovery to be producing nearly normal crops. The orchard that was surveyed in 1954 was surveyed again in 1955, and 67 new infections were discovered. Nineteen trees that showed symptoms the previous year appeared to have recovered. The disease in 1955 seemed to be increasing rapidly, but a check of the orchard early in 1956 indicated that infected trees have continued to recover. Dying of branches or trees that could be directly related to the presence of the fungus has rarely occurred in Oregon.

The original source of fungus inoculum in this orchard was thought to be native Oregon oak, Quercus garryana Dougl., which had been cut down in the immediate vicinity. The oak was a symptomless host and the fungus fruiting bodies were found only on dead wood.

Burning diseased prunings, and treating broken limbs and cuts with grafting wax or Bordeaux paint, have been recommended for control. Attempts were made to reduce the disease incidence with spray applications of 25 pounds of zinc sulfate per 100 gallons of water applied when the trees were dormant. Recovery seemed to be more rapid and disease symptoms less severe on the sprayed trees than on the checks, but the general improvement of the entire orchard prevented any definite conclusions.

Trees treated with 8-hydroxyquinoline sulfate, in solution, as suggested by Grosjean (8), did not express symptoms in the year following treatment but have not been under observation long enough to determine if the fungus has been eliminated.

In Oregon, as in the Netherlands (9), warm summer temperatures seem to be sufficient to keep the fungus in check and to allow most infected trees to recover eventually without additional treatment.

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OREGON STATE COLLEGE, CORVALLIS, OREGON

EFFECTS OF HIGH SOIL TEMPERATURE ON ROOT GROWTH OF LOQUAT SEEDLINGS IN NURSERY CONTAINERS

R. L. Self and H. S. Ward, Jr.[1]

Summary

Temperatures above 35° C were recorded in the soils of green and black cans exposed to high solar radiation. Examination of the root systems of 1-year-old loquat seedlings grown in the cans revealed that root growth was retarded on the side exposed to direct radiation. In the same cans, root growth was extensive on the shaded side (soil temperatures near 30° C), resulting in a one-sided pattern of root development. Soil temperatures above 30° C for periods of more than 2 to 4 hours have been reported to cause partial to complete cessation of growth. This appears to be the explanation for the one-sided root growth of the loquat seedlings. Other container-grown plants exhibit a similar pattern of root growth.

Introduction

The one-sided root growth of container-grown Japanese holly (Ilex crenata Thunb. var. rotundifolia, Hort.) was first called to the authors' attention by James S. Tate of Blackwell Nurseries. A survey in the Mobile area in 1954 and 1955 revealed that the unequal growth of root systems of ornamental plants grown in containers was a common problem in nurseries. Further observations showed that the retardation of root growth occurred in the soil that was in contact with the side of the can exposed to direct solar radiation, i.e. with southern to southwestern exposures. The root condition caused by high temperatures is similar to that resulting from water deficits and physiological drought (overfertilization).

The ecological effects of temperature and its importance as an environmental factor have been discussed by Allee et al. (1) and Daubenmire (2). Daubenmire (2) described high temperature injury to the roots of plants growing in containers exposed to direct insolation. Recent reviews by Kramer (3) and by Richards et al. (4) on the effect of temperature on root growth indicate that optimum growth of roots for most higher plants is between 25° and 30° C, with cessation of growth at either 0° or 40° C. Root growth from the plant physiological point of view has been discussed by Stiles (6) and Went (7). Decreasing rates of growth with increases of temperature above 30° C have been largely attributed to growth being an enzymatically controlled process (5).

Studies of the high temperature effects on root growth of loquat (Eriobotrya japonica Lindl.) in containers were carried out in 1955 at the Ornamental Horticultural Field Station, Spring Hill, Alabama.

Materials and Methods

One-year loquat seedlings were grown in green, black, and unpainted cans. On October 20, 1955, soil temperatures were taken with soil thermometers at a 3-inch depth, 1 inch from the edge of the cans. Readings were taken from 2:00 to 2:30 p.m. The weather was clear and calm. Soil moisture, except for a few of the cans, was optimum for plant growth.

Several of the loquat seedlings from the painted and unpainted cans were removed from the cans and observations were made on the distribution of root growth in relation to exposure. The root systems were photographed to show the effect of high temperature on root growth.

Results

Temperatures of soils in nursery can containers were affected by can color, position of can in beds, exposure to solar radiation, and soil moisture content (Table 1).

The highest soil temperatures occurred in the western side of cans that were in the outer

[1] Plant Pathologist in Charge, Ornamental Horticulture Field Station, and Botanist, Department of Botany and Plant Pathology respectively, Agricultural Experiment Station of the Alabama Polytechnic Institute, Spring Hill, and Auburn, Alabama.

FIGURE 1. Root growth of loquat seedlings in black nursery containers. The extensive root growth of the plant at left is on the north-exposed side of the can. The retarded root growth of the plant on the right is on the southwest-exposed side.

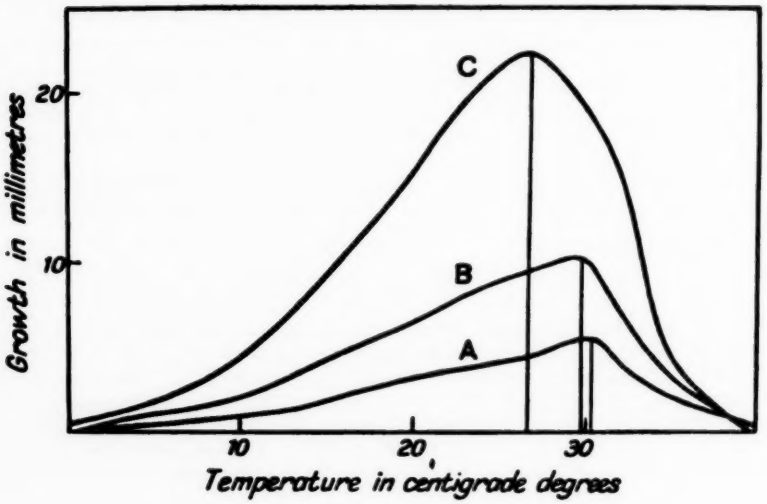

FIGURE 2. Relation of time to temperature effect on the growth of Lepidium roots. Growth after (A) 3.5 hours, (B) 7 hours, and (C) 14 hours. (From Stiles, Walter. 1950. An Introduction to the Principles of Plant Physiology. 2nd Ed. Methuen and Co., Ltd.).

Table 1. Soil temperature of green, black, and unpainted cans with loquat seedlings on October 20, 1955 from 2:00 to 2:30 p.m. with an air temperature of 29.4° to 30.6° C.

Can color and size	Can exposure	Condition of soil moisture	Temperature[a] of soil in degrees C. West side	East side
Green, 2 gallon	West	Dry	40.0	33.0
	"	"	38.9	33.9
	"	Optimum	33.9	28.0
	"	"	33.9	29.4
	"	"	36.1	32.2
	"	"	30.0	28.3
Black, 1 gallon	West	Optimum	40.0	33.0
	"	"	43.0	34.0
	"	"	45.6	34.0
	Southwest	"	45.0	37.8
	North	"	28.3	28.3
	"	"	29.4	28.9
	"	"	26.7	26.0
Unpainted, 4 gallon	West	Optimum	28.3	21.7
	"	"	33.3	24.4
	"	Dry	32.0	28.9
	"	"	35.0	26.0
	Middle of bed	Optimum	23.3	22.8
	"	"	26.1	23.9
	"	"	25.0	22.2

[a] At 3-inch depth and 1 inch from edge of can.

rows of beds and in the rows having western and southwestern exposures. Soil temperatures in cans in the middle of the beds and in outer rows facing north were near air temperatures or several degrees cooler. Soil temperatures on the western side of fully exposed cans were highest (10° to 15° C above air temperatures) in black containers, lowest (2° to 5° C above air temperatures) in unpainted containers, and intermediate (4° to 10° C above air temperature) in green containers. Temperatures in dry soils were 4° to 7° C warmer than temperature in soils of optimum moisture content.

Examination of roots of loquat seedlings grown under optimum soil moisture conditions in black containers revealed a one-sided root growth condition (Fig. 1). The distribution of the root systems shown in Figure 1 indicated that root growth was retarded on the southwestern side of the can while good growth occurred on the northern side.

Discussion

The retardation of root growth of loquat seedlings by soil temperatures above 30° C on the side exposed to solar radiation in black and green nursery containers was similar to the results observed by other investigators (3,4,6). Growth of roots at temperatures above 30° C may be increased for short periods of time. However, for periods of more than 2 to 4 hours

the optimum temperature for growth is usually less than 30° C. According to Stiles (6), the optimum temperature for root growth by Lepidium was 26° and 28° C for periods of 7 and 14 hours respectively. Stiles' data in Figure 2 illustrate the time-temperature relationship.

To reduce the retardation of root growth from high soil temperatures, it is suggested that unpainted or light colored cans be used. Soil temperatures can be lowered by orienting the beds of cans north and south, by shielding the cans on the south and west sides with boards, cuprotox-treated burlap, or shavings, or by burying the cans in the ground or in sawdust.

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ORNAMENTAL HORTICULTURE FIELD STATION AND DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, AGRICULTURAL EXPERIMENT STATION OF THE ALABAMA POLYTECHNIC INSTITUTE, SPRING HILL, AND AUBURN, ALABAMA

FIELD TESTS OF CONTACT FUNGICIDES FOR PECAN SCAB CONTROL

Richard H. Converse[1, 2]

Summary

Three materials that showed promise as contact fungicides[3] -- Corona CM-220, Puratized Agricultural Spray, and Dowicide G -- were selected for a field test in 1955. Each material was applied twice as a dormant spray and was followed by five summer protectant sprays of ziram. All contact fungicides virtually eliminated the spore production of holdover stromata on which they were sprayed. Used consecutively, contact and protectant fungicides gave excellent control of scab during the growing season. Corona CM-220 used alone gave control similar to control by the protectant fungicide, ziram, used alone. Residues of As and Hg were detected in pasture grass beneath sprayed trees 6 weeks after application, but no phytotoxicity to the pecan trees was observed, and no As or Hg was found in the nuts harvested from the sprayed trees.

The holdover stromata of Cladosporium effusum (Wint.) Demaree on twigs, nut shucks, and leaf parts have been found to be the sources of the inoculum from which the first scab lesions develop on spring growth of pecan trees (3). A preliminary field test indicated that spraying with certain contact fungicides in the dormant season would reduce the number of sporulating stromata to a very low level and thus would decrease considerably the infection of new shoot growth (1). Additional information has been obtained since then concerning the laboratory and field performance of contact fungicides against this fungus. An abstract covering part of this work has appeared (2).

Materials and Methods

Mature pecan trees of the variety Squirrel not sprayed in 1954 and having active holdover stromata on twigs in March 1955 were used for a field test of contact fungicides in 1955. For all contact-fungicide sprays except one, 2 applications each of approximately 50 gallons of spray mixture were applied 9 days apart to each tree and to the ground immediately around it in a circle having a radius of 15 feet. Both sprays were applied in late March before budbreak with a high-pressure hydraulic sprayer. Each treatment was applied to 5 trees in a randomized-block experimental design. The ability of holdover stromata to produce conidia was determined at intervals during the spring by incubating nut shucks in petri-dish moist chambers at 25° C for 24 hours and then counting the sporulating stromata. The percentage of the conidia germinating was determined after incubation of the conidia on water agar at 25° C for 24 hours. A mid-August count of scab lesions on nuts chosen at random from the lower branches was used for the final evaluation of the spray treatments.

Seven different spray treatments were used in the test. In all cases where a protectant spray schedule was used ziram (as Zerlate at the rate of 2 pounds per 100 gallons of water) was used in a 5-spray schedule. The treatments were; 1, no fungicide; 2, Corona CM-220 (3 pounds per 100 gallons of water); 3, ziram only; 4, Corona CM-220 (3 pounds per 100 gallons of water) followed by ziram; 5, Puratized Agricultural Spray (5 pints per 100 gallons of water) followed by ziram; 6, Dowicide G (4.5 pounds plus 1 gallon of dormant oil emulsion per 100 gallons of water) followed by ziram; and 7, Corona CM-220 (3 pounds per 100 gallons of water) applied to the trees and to the ground around them throughout an entire block of 5 trees, fol-

[1] The author is indebted to Dr. H. E. Hammar, United States Department of Agriculture, Pecan Field Station, Shreveport, Louisiana, for valuable assistance in the determination of fungicidal residues.

[2] Assistant Plant Pathologist, Oklahoma A. and M. College and Agent, United States Department of Agriculture.

[3] The phrase "contact fungicides" is used in the sense of J. G. Horsfall (1956, "Principles of Fungicidal Action" Waltham, Chronica Botanica Co.) to include materials that destroy the resting stages of fungi. The term replaces the phrase "eradicant fungicides", previously used to denote this group of materials.

Table 1. Sporulation levels of overwintered stromata of C. effusum on twigs of Squirrel pecan sprayed twice with three contact fungicides, Paden, Oklahoma, 1955.

Date	Spraying or rating	Sporulation level[a] of stromata sprayed with-		
		Corona CM-220	Dowicide G	Puratized Agricultural Spray
March 15	First spraying	-	-	-
March 24	Second spraying	-	-	-
March 25	First sporulation rating	4	2	0
April 14	Second sporulation rating	4	14	0
May 4	Third sporulation rating	3	0	0

[a] Level on stromata sprayed only with ziram = 100.

Table 2. Scab lesions on August 18, 1955, on nuts from Squirrel pecan trees sprayed with contact, protectant, and combined spray schedules, Paden, Oklahoma.

Treatment	Average number of scab lesions per nut
Tree and ground spray of Corona CM-220 + ziram[a]	0.01[b]
Dowicide G + ziram	0.3
Corona CM-220 + ziram	0.6
Puratized Agricultural Spray + ziram	0.9
Ziram only	2.5
Corona CM-220 only	5.9
No fungicide	88.7

[a] Adjoining but not in the same field plot design as the other treatments.

[b] The difference between any 2 means not occurring together in the same bracket is significant at the 5% level. The differences between the means and the unsprayed control mean are significant at the 1% level.

lowed by ziram.

The chemical composition and origin of the materials are as follows:

Corona CM-220 (monocalcium meta-arsenite) -- Corona Chemical Division, Pittsburgh Plate Glass Co., Moorestown, New Jersey.
Zerlate (ziram) -- E. I. du Pont de Nemours & Co., Wilmington, Delaware.
Puratized Agricultural Spray (tris (2-hydroxyethyl) (phenylmercuri) ammonium lactate) -- Gallowhur Chemical Co., Ossining, New York.
Dowicide G (sodium pentachlorophenoxide) -- Dow Chemical Co., Midland, Michigan.
Standard Dormant Spray Oil No. 1(dormant oil emulsion) -- Standard Oil Co. of Indiana, Chicago, Illinois.

Mercury in pasture grass samples from sprayed pecan tree plots and in pecan kernels from sprayed trees was determined by the colorimetric method of Polley and Miller (5). A Klett-Summerson photoelectric colorimeter was used with a green filter. Arsenic in grass and pecan kernel samples was determined by the modified Gutzeit method (6). Two- to 4-replicate analyses of each sample were performed.

Results

The capacity of holdover scab stromata on twig lesions obtained from trees in the test plot to produce spores was determined at intervals during the spring (Table 1). The production and germination rate of spores from twig-lesion stromata from trees sprayed only with ziram was consistently high. Spores from stromata on twigs that had been sprayed with contact fungicides were either absent or failed to germinate. The sporulation on twig stromata was zero throughout the observation period following the applications of Puratized Agricultural Spray. On nut shucks the effects of the contact fungicides on the production and germination of spores on holdover stromata were similar to those on twig lesions. The control of sporulation on nut shucks generally was not so complete as control on twig lesions, however; and on April 14 a high level of spore germination was found in shuck samples from plots sprayed with Corona CM-220.

Scab lesions on nuts were counted on August 18, 1955 (Table 2). All spray treatments were highly significantly different from the control treatment. When the multiple range test of significance (4) was applied to all randomized-block spray treatments except the control, the three contact-plus-protectant treatments (Corona CM-220, Puratized Agricultural Spray, and Dowicide G, each followed by ziram) fell into a statistically homogeneous group. Corona CM-220 alone and ziram alone fell into a second group, but ziram and the three contact-plus-protectant treatments also consituted a statistically homogeneous group. The Corona CM-220 ground spray plot adjoined but was not a part of the same experimental design as the other treatments; hence it cannot be compared statistically with the other treatments.

It is noteworthy that the use of contact fungicidal sprays alone resulted in a control level that was statistically similar to the standard ziram protectant treatment. The combination of contact and protectant sprays provided better control of scab than when a contact fungicide was used alone. When all the ground, as well as the trees in a block of trees, was sprayed twice with Corona CM-220 in the dormant season and the trees were subsequently sprayed five times with ziram, the incidence of scab was at a very low level (3 lesions on 200 nuts examined on 5 trees).

The development of pecan scab on nuts was only moderate in the Paden, Oklahoma, plots in 1955, and almost no scab was found on foliage in the test plots. Statistical analysis of the yield data indicated that there were no significant differences between treatments. All conclusions are therefore drawn from lesion counts alone. None of the pecan trees sprayed with any of the contact fungicides showed symptoms of phytotoxicity at any time during the growing season. However, pasture grass was damaged beneath trees sprayed with Corona CM-220 and Dowicide G.

As pecan orchards are usually sown to some kind of cover crop plant or to grass, and are pastured, the residue levels left on plants on the orchard floor after the application of contact fungicides is a matter of importance. The arsenic and mercury residue levels from Corona CM-220 and Puratized Agricultural Spray treatments, respectively, were determined on grass samples collected periodically for a 6-week period after spraying. By the end of 6 weeks, on a dry-weight basis, the As level had fallen from an initial level of 1885 ppm to 11.5 ppm and the Hg level from 293 to 3.5 ppm. From these studies the minimum length of time before no residue could be detected in grass from an orchard sprayed with Corona CM-220 or Puratized

Agricultural Spray would be longer than 6 weeks. The As and Hg levels were nil in mature pecan kernels from nuts harvested from treated trees at the end of the growing season.

Discussion

A critical evaluation of contact fungicides for the commercial control of pecan scab can only be made in orchard tests in years of heavy infection. In 1955, a year of relatively moderate scab incidence in the Paden, Oklahoma, spray plots, the use of contact fungicides alone afforded satisfactory control.

In a field test in 1956 similar to that described above, a schedule consisting of only two spray applications of the contact fungicides Puratized Agricultural Spray or Dowicide G afforded excellent control of pecan scab until the end of June. By late August, however, without the addition of a summer protectant schedule, the severity of scab on nut shucks was the same on the trees receiving the contact fungicides as on those left unsprayed.

It is probable that in a season favorable to the development of the disease contact fungicides would be ineffective alone but would be valuable adjuncts to a protectant spray program.

The principal factors presently limiting the commercial use of eradicant fungicides in pecan orchards would seem to be the levels of toxicants occurring on the forage plants beneath sprayed trees in the orchards and the cost of certain promising contact fungicides. The ideal fungicide would be one that decomposed quickly after exerting its eradicant effect and that was relatively inexpensive. A search for such materials is being conducted at this Station.

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OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE, AND UNITED STATES DEPARTMENT OF AGRICULTURE

NUT DISEASES IN OREGON AND WASHINGTON IN 1956

P. W. Miller[1]

WALNUT DISEASES

Walnut Blight (Xanthomonas juglandis (Pierce) Dowson) was widely distributed, causing greater economic loss than in the 2 preceding years. Losses of nuts from this disease in non-sprayed orchards varied, according to locality, from 5 to 40 percent.

Mushroom Root Rot (Armillaria mellea (Fr.) Quel.) caused the decline and death of a small percentage of Persian walnut trees (Juglans regia) grafted on Hinds black walnut (Juglans hindsii) or Persian walnut rootstocks.

Leaf Scorch (non-parasitic) was widely distributed in western Oregon where it occurred in most Persian walnut orchards. However, it was not so prevalent or severe as in 1955.

Blackline of Grafted Walnuts (non-parasitic) was widespread, occurring in practically all walnut-growing districts. However, the number of new cases of blackline found was not so great as in the 2 preceding years. It occurred only on Persian walnut trees grafted on black walnut rootstocks (J. hindsii or J. nigra) or on hybrids between these and other species. One case was found in a tree of the Franquette variety grafted on a Paradox hybrid walnut rootstock (J. regia x J. hindsii). Not a single case of blackline was found in Persian walnuts on Persian (J. regia) rootstocks.

The disorder was found in orchards growing on practically all soil series in western Oregon, but was more prevalent on the Olympic soil series than on any other. Incidence was greater in Franquette trees on Hinds black walnut rootstocks than in Mayette trees on the same rootstock.

Crown Rot (cause undetermined). A crown and collar rot of undetermined cause was found affecting a limited number of Persian walnuts on Hinds black walnut rootstocks and some Persian seedling walnuts.

Downy Spot (Microstroma juglandis (Bereng.) Sacc.). This leaf spot occurred in limited amounts in a few walnut orchards in the Willamette Valley but was of no economic importance since it did not cause any defoliation or decrease the functional leaf area appreciably.

Cold Injury. An unseasonably early cold period in Oregon and Washington on November 15, 1955, when the trees were in full leaf, was responsible for the death of many walnut trees in the northern part of western Oregon and in Washington. Nearly all Persian (English) walnut trees were severely damaged. During the cold period, minimum temperatures of 7° to 9° F occurred. The damage was generally worse in the hill orchards than in orchards on the valley floor.

FILBERT DISEASES

Bacterial Blight (Xanthomonas corylina (P. W. Miller et al.) Dowson) was widely distributed in western Oregon, occurring in most filbert orchards.

Powdery Mildew (Phyllactinia corylea Karst.) occurred in numerous filbert orchards in western Oregon, but was of no economic importance as it did not appear until near the end of the season and the leaves persisted on the trees until the time of normal leaf fall.

Brown Stain (non-parasitic) was present in greater than normal amounts. Crop losses ranged from less than 1 up to 10 percent, the estimated average loss being about 3 percent.

Leaf Scald (non-parasitic) was widely distributed and very severe. Its appearance after the occurrence of abnormally high temperatures during the middle of July indicates that high temperature is associated with its development. It was worse in orchards on relatively shallow soils with low reserves of soil moisture.

Cold Injury. The unseasonably early cold which occurred in Oregon and Washington on November 15, 1955, when the trees were in full leaf, caused considerable injury to many filbert trees in the northern part of western Oregon and in Washington. The catkins, twigs, and small branches were the parts injured most.

HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, OREGON STATE COLLEGE, CORVALLIS, OREGON

[1] Plant Pathologist, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Oregon State College, Corvallis, Oregon.

VIABILITY OF ENCYSTED GOLDEN NEMATODE LARVAE FOLLOWING SEASONAL TEMPERATURE CHANGES AND DROUGHT

J. M. Ferris[1] and W. F. Mai[2]

Abstract

Seasonal changes in soil temperature and variations in rainfall were simulated to determine their effects on reproduction of the golden nematode (Heterodera rostochiensis Wollenw.) in potato plants. At a low series of temperatures a significantly greater number of larvae were produced than at higher temperatures. At the higher temperatures, where temperature itself appeared to be a retarding factor, a moisture effect could not be shown.

A decrease in golden nematode cyst viability at the Golden Nematode Research Laboratory, Seaford, New York, was noted following two warm, dry growing seasons (3). In order to study further the effects of such weather on cyst viability, changes in soil temperature and variations in rainfall that might occur during a growing season on Long Island were simulated in temperature tanks. Some potato plants were grown at soil temperatures higher than those calculated as average from records of preceding seasons, and some were grown at temperatures lower than average. The experiment was designed to determine the effect on reproduction of the golden nematode of a 2-week drought at certain periods during the growing season, and whether the effect of a given dry period was the same on nematodes developing at the higher and lower temperatures.

Materials and Methods

Fertilizer and vermiculite were mixed with field soil naturally infested with golden nematode cysts. The soil contained approximately 230 cysts per 2 ounces, and 6 percent of the cysts contained viable larvae[3]. Two months before the start of the experiment, Cobbler seed pieces were planted in flats of golden nematode-free soil. At the start of the experiment plants, uniform in size, were selected, and one transplanted to each of 56 1-gallon glazed crocks filled with the infested soil mixture. The crocks with plants were then placed in a water bath in milk coolers adapted to serve as temperature tanks (2). The greenhouse in which the tanks were located was insulated and heavy coatings of whitewash put on the glass. Over each tank two banks of four 40-watt fluorescent bulbs were suspended to provide light for plant growth. The lights were kept on 19 hours a day.

The average Long Island soil temperature at a depth of 6 inches was obtained for each 2-week period during the months of May through August, from soil temperature records for 1950 to 1952 inclusive. One set of tanks was maintained at temperatures 5° F. below the seasonal average, and another set at 5° F. above the average. The 56 plants were divided into 2 groups of 28 plants each. One group was grown at the lower temperatures, and the other group at the higher temperatures. Thus the two groups of plants were grown at temperatures 10° F. apart during each 2-week period throughout the simulated season (Table 1).

To study the effect of moisture on the development of viable cysts, the plants in each set of temperature tanks maintained at a like temperature were divided into 7 groups (A through G, Table 1), each containing 4 plants. One group (A) in each set of tanks was designed as the check. The check plants all received sufficient water during the period of the experiment to promote good growth. The remaining plants received normal amounts of water throughout the experiment except for one 2-week dry period, which occurred at a different time for each of the 6 groups (B through G). The periods were begun 2 weeks after the plants were transplanted to the infested soil in the temperature tanks (Table 1). During a dry period the soil in a crock was allowed to dry until the plants wilted. The plants received only enough water to keep them alive. At the end of a dry period the plants again received normal amounts of

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[1] Formerly Research Assistant in Plant Pathology, Cornell University.

[2] Professor of Plant Pathology, Cornell University.

[3] Viability is determined by examining the contents of 100 cysts. If a single viable larva is found, the cyst is considered viable.

water. The amount of water added to each plant was recorded daily throughout the experiment.

The plants were grown for a total of 112 days. They were then cut off at the soil line and the soil in the crocks was allowed to dry. Several months later the soil in each crock was mixed and a 2-ounce sample taken. The cysts were washed out of each soil sample and placed in a Petri dish. Potato leachings were added to the dishes of cyst material, and the number of emerged larvae counted at the end of 2 weeks.

Experimental Results

It was calculated that each 586 ml of water added to a gallon crock was equivalent to 1 inch of rainfall. The check plants growing at the lower temperatures received an amount equal to an average of 0.53 inches of rainfall per week. The precise amount of water received by these plants ranged from 0.00 to a maximum of 1.02 inches per week. The check plants at the higher temperatures received an amount of water equal to an average of 0.70 inches per week. The range for these plants was 0.26 to 1.02 inches per week. The amount of water for the plants receiving the drought treatments at the lower temperatures averaged an equivalent of 0.00 to 0.60 inches of rainfall per week during the 2-week dry period. The range for the plants receiving the drought treatment at the higher temperatures averaged 0.00 to 0.81 inches per week during the 2-week dry period. This water was required to keep the wilted plants from dying.

The averages for the number of larvae which hatched from a 2-ounce sample from each of 4 replications are given in Table 1. The average number of larvae hatched at the lower temperatures was 2523, and the average at the higher temperatures 982. The difference between the number of larvae hatching at the lower temperatures and at the higher temperatures was found to be statistically significant when analyzed using Student's "t" test.

The differences due to treatments and within replications were analyzed using an analysis of variance method. At the higher temperatures the differences due to drought were not found to be significant. At the lower temperatures, however, the differences due to drought treatment were highly significant.

At the lower temperatures the smallest larval hatch was obtained from cysts that had developed on plants exposed to the first drought treatment (period II, Table 1). The greatest hatch was obtained from cysts from plants exposed to the last dry treatment (during period VII). The next highest hatch was from the cysts of the check plants.

The differences within replications were not significant for either the lower or the higher temperatures.

Discussion

There were no differences in the larval counts from cysts of plants grown at the higher temperatures that could be attributed to the different moisture treatments. Furthermore, a significantly smaller average hatch was obtained from these cysts than from those which developed at the lower temperatures. It would appear that with the plants grown at the higher temperatures, temperature itself was a retarding factor in the development of the nematode (1), and a moisture effect could not be demonstrated.

At the lower temperatures the highest larval hatch was from cysts which developed on the plants exposed to the last drought treatment (period VII). As the hatching from these cysts was higher than that obtained with cysts of the check plants, the dry period during the thirteenth and fourteenth weeks may actually have stimulated in some way the maturation of the eggs within the cysts.

The smallest larval hatch was obtained from plants exposed to the first drought treatment (period II), during the third and fourth weeks. The early dry period combined with the very low soil temperature right after transplanting may have had a deleterious effect on the roots of these plants. A stunted root system might result in a small number of viable cysts.

The numbers of larvae that hatched from cysts of plants dried during the period from the fifth to the twelfth weeks (periods III to VI) did not differ significantly from those that hatched from cysts of the check plants.

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Table 1. Number of larvae hatched, from cysts of the golden nematode produced on potato plants, following simultaneous tests in which different growing seasons were simulated by varying temperature and moisture conditions.

Group	Moisture conditions[a] in successive 2-week periods during a simulated growing season[b] in which the temperature for each period was as indicated (°F)								Average no. of larvae hatched from cysts in 2 oz. of soil
	I	II	III	IV	V	VI	VII	VIII	
	50°	50°	55°	60°	65°	65°	65°	60°	
	(Low temperature series)								
A (Check)	Opt	Opt	Opt	Opt	Opt	Opt	Opt	Opt	2968
B	Opt	Dry	Opt	Opt	Opt	Opt	Opt	Opt	1142
C	Opt	Opt	Dry	Opt	Opt	Opt	Opt	Opt	2244
D	Opt	Opt	Opt	Dry	Opt	Opt	Opt	Opt	2207
E	Opt	Opt	Opt	Opt	Dry	Opt	Opt	Opt	2098
F	Opt	Opt	Opt	Opt	Opt	Dry	Opt	Opt	1628
G	Opt	Opt	Opt	Opt	Opt	Opt	Dry	Opt	5373
							Average of treatments		2523
							L.S.D. 5%		1409
							L.S.D. 1%		1930

	60°	60°	65°	70°	75°	75°	75°	70°	
				(High temperature series)					
A (Check)	Opt	Opt	Opt	Opt	Opt	Opt	Opt	Opt	542
B	Opt	Dry	Opt	Opt	Opt	Opt	Opt	Opt	720
C	Opt	Opt	Dry	Opt	Opt	Opt	Opt	Opt	1634
D	Opt	Opt	Opt	Dry	Opt	Opt	Opt	Opt	658
E	Opt	Opt	Opt	Opt	Dry	Opt	Opt	Opt	1049
F	Opt	Opt	Opt	Opt	Opt	Dry	Opt	Opt	1218
G	Opt	Opt	Opt	Opt	Opt	Opt	Dry	Opt	1050
							Average of treatments		982

[a] Moisture conditions indicated in the table: "Opt," plants watered according to best greenhouse practices, plants received sufficient water to promote good growth; "Dry," plants allowed to dry until they wilted, plants received only enough water to keep them alive.

[b] Month simulated: May, periods I and II; June, periods III and IV; July, periods V and VI; August, periods VII and VIII.

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DEPARTMENT OF PLANT PATHOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK

CYST-FORMING NEMATODES IN ISRAEL[1]

G. Minz[2]

Abstract

Cyst-forming nematodes found with their respective hosts in Israel are: Heterodera avenae on vulgare wheat; H. cacti on Mammillaria spp.; H. rostochiensis on potato; H. schachtii on sugar beets; and probably H. schachtii var. trifolii on sweetpeas. The frequent occurrence in soil under non-host plants of H. avenae, H. schachtii, and probably H. humuli and H. schachtii var. trifolii, might be traced to the native wild hosts of these nematodes.

Root-knot nematodes (Meloidogyne spp.), a nuisance to a wide variety of crops in Israel, were until 1955 generally the only forms investigated on plant roots. Nematodes other than root-knot found in Israel were Anguina tritici (Steinbuch, 1799) Filipjev, 1936, in wheat kernels, Aphelenchoides sp. in leaves of Salvia sp. and Dahlia variabilis (6), and Ditylenchus dipsaci (Kuehn, 1857) Filipjev, 1936, in White narcissus leaves.

The presence of cyst-forming nematodes in Israel was known only from files of the Section of Nematology at Beltsville, Maryland, where material intercepted at United States entry points was examined during the period December 1950 to May 1954. The following Heterodera spp. were found in soil with plants from Israel: (a) H. cacti, (b) H. punctata (not found here during our investigations, (c) H. ?avenae, (d) Heterodera sp. (schachtii group).

Nematodes other than cyst-forming constitute a separate paper; herein are reported the cyst-forming nematodes, both on plants and in surrounding soil.

METHODS

A survey covering 22 representative places throughout the country was begun in the second half of 1955. Soil was collected from farms with a known crop history, including potatoes originating from imported seed material. Very often soil was brought in with the diseased plants, in which case a full analysis of the nematodes present was made.

The cysts were collected either during the sieving process on 50-, 60-, or 85-mesh screen from a sample of 300-500 g of soil, or by flotation of 50-100 g of air-dried soil. In this way many cysts were found in soil under plants not specifically hosts of the nematodes. In other cases, when cysts were found along with their possible hosts, a search was made to discover either the relation of cysts to the roots, or the presence of cyst masses in soil around the roots.

Cysts for which there was insufficient material (especially lack of larvae) were identified to group only (1).

RESULTS

Heterodera spp. with Plants

1. Heterodera avenae Filipjev, 1934 (syn. H. major (O. Schmidt, 1930) Franklin, 1940). This nematode was found first in soil under various plants. When it was discovered in a field which was at that time under wheat, the wheat plants were thereafter periodically examined.

Roots were filled with white immature cysts, which gradually became deep brown in color and contained eggs and larvae.

The surrounding soil was later examined for cysts. In three 50-g samples of dry soil, 20, 12, and 20 viable cysts, respectively were found, i.e. about 70 cysts per 200 g of dry soil, which might be regarded, according to European standards for oats (9), as a very high infestation.

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[1] Publication of the Agricultural Research Station, Rehovot, Israel, 1956 Ser. No. 163.

[2] Plant Pathologist, Division of Plant Pathology, Agricultural Research Station, Rehovot, Israel.

Some of the identifications reported in this paper were confirmed, some elucidated and discussed, and some were made by Mr. A. L. Taylor, Horticultural Crops Research Branch, Agricultural Research Service, Plant Industry Station, Beltsville, Maryland, U. S. A.

The wheat, a vulgare type (Florence Aurore), received additional irrigation throughout the growing season (November-May). This might explain the relatively high yield, about 1.2 tons per acre, in spite of the large nematode population.

It is surprising that this nematode, which is susceptible to dryness (3,5), was able to survive the very hot and dry summer of its locality (near Be'er Sheva, 31° 20' N).

2. Heterodera cacti Filipjev & Schuurmans-Stekhoven, 1941. This nematode (cysts only) was found in soil potted to various cacti (see next section), but it was found both in roots and as masses in the soil with Mammillaria spp. With M. gracilis, 336 cysts were found in 50 cc of dry soil from a 4-inch pot. Similar amounts of cysts were found with M. hahniana and M. pringlei, both in identical pots.

3. Heterodera schachtii Schmidt, 1871, was found in soil closely sticking to sugar beets.

4. Heterodera sp. (schachtii group, probably var. trifolii) was found in roots of sweet-pea (Lathyrus odoratus) along with Meloidogyne arenaria, M. incognita var. acrita, and with one female, probably a new genus, resembling both Meloidogyne and Heterodera (10).

Heterodera spp. in Soil

1. Heterodera avenae was found in soil around the following plants: Alfalfa, banana, barley, lettuce, peanut, potato, St. Augustine grass, strawberry, tomato, and wheat.

2. Heterodera cacti was found in soil with potted plants: Cereus sp., Coryphantha elephantidens, Faucaria boscheana, Opuntia depauperata, and tuberose (in vicinity of the cactus plantation).

3. Heterodera sp. (goettingiana group) was found in soil under the following plants: bitter almond, lettuce, potato, and Rosmarinus sp.

With the bitter almond stock the larvae were 400-460 μ long, had an ancor stylet 22 μ and tail terminal about 18 μ. It is possible that the cysts are closely related to H. fici Kiryanova, 1954, recently described in Russia (11).

In the case of the cysts from soil with Rosmarinus, larvae measured about 300 μ, which corresponds closely with H. humuli Filipjev, 1941 (2). Urtica spp., hosts of this species (4), are widespread in Israel.

4. Heterodera rostochiensis Wollenweber, 1923, was found in a citrus nursery soil, in which potatoes had previously been grown for more than ten years (7,8).

5. Heterodera schachtii was found in soil from banana, barley, oats, Opuntia depauperata, peanut, pepper, potato, tomato, strawberry, sugar beet, and wheat.

6. ?Heterodera schachtii var. trifolii Goffart, 1932. Cysts of the schachtii group, the larvae of which measured approximately 500 μ (2), were frequently encountered during the winter rainy season and in irrigated soils. The leguminous plants are widespread during the winter season over all the country; it is therefore possible that these cysts belong to this form.

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AGRICULTURAL RESEARCH STATION, REHOVOT, ISRAEL

PRELIMINARY FIELD TESTS FOR EVALUATING SOME TOMATO VARIETIES FOR RESISTANCE TO ROOT-KNOT NEMATODES, MELOIDOGYNE SPP.

Hussein H. Houssny[1] and Bakir A. Oteifa

Summary

Several tomato varieties were tested in a field experiment for evaluating their degree of resistance to natural root-knot nematode populations of Giza, Egypt. Four species only were present in this area, of which the Javanese root-knot nematode, Meloidogyne javanica, was found to be the predominant species. The variety Pearl Harbor showed a high degree of resistance to all four species. The Urbana and Illinois T 19 varieties were intermediately susceptible to M. javanica and M. hapla but quite tolerant to M. incognita var. acrita.

Tomato fields in most sandy loam textured soils of Egypt are known to be infested with root-knot nematodes. Although the nematodes rarely cause direct death, they weaken the plants to an extent that they are easily destroyed by other factors. The degree of infection has varied from very light to heavy depending upon several factors, namely soil condition, cropping practice prior to cultivation, rotation of crops, and variety of tomato grown. Three major tomato varieties are widely grown in Egypt. These varieties are Baladi, Pritchard, and North Dakota. They are very susceptible to root-knot nematodes.

This paper is a brief report of a detailed study on the relative susceptibility of some imported tomato varieties to the natural root-knot nematode population under field conditions.

Procedure

The tests here reported were conducted during the spring of 1953 in a portion of a field at the Faculty of Agriculture Farm Station, Giza, Egypt. The soil of the field is a textured sandy loam very favorable for root-knot development. A moderately high root-knot nematode population was built up in this land by growing vegetable crops known to be very susceptible to the nematodes.

Tomato varieties imported from the United States Department of Agriculture were tested for their degree of susceptibility. Plants grown from seeds sown in beds in March 1953 were transplanted to the field plots in May 1953, in a randomized design. On October 1953 the plants were carefully removed and a visual root-knot index was made for each plant. This index was based on the relative amount of root galling, classified as follows: 0 -- no evidence of galling; 1 -- trace of galling; 2 -- moderate galling; 3 -- extensive galling; and 4 -- severe galling. Ten plants from each variety were brought to the laboratory for the identification of their root-knot nematode species. The percentages of occurrence of the species involved were determined after at least ten nematode specimens from each plant were examined.

Results

The results reported here are only a part of a much more detailed study which is not yet completed. It was felt that such field tests of many strains of tomatoes for resistance to nematode have been of some value in preliminary investigations. However, data from such field tests could be erratic in value for other locations because of different ecological conditions that cause variations in the activity of the different root-knot nematode species. For this reason further work is necessary to design an artificial inoculation experiment in a greenhouse for evaluating the nematode resistance of numerous breeding populations of tomatoes. The greenhouse method is still under experimentation.

Some of the field results were so striking that we feel they should be reported. Table 1 shows the mean root-knot index and the percentage occurrence of Meloidogyne spp. for the

[1] Late Lecturer of Vegetable crops, Horticulture Division, Faculty of Agriculture, Cairo University.

Table 1. Relative susceptibility of 13 tomato varieties to natural populations of root-knot nematodes, Meloidogyne spp., in plots at Giza, Egypt.

Variety	Mean root-knot index	Percentage occurrence of Meloidogyne spp.			
		javanica	incognita	incognita acrita	hapla
Webb Special	1.05	70	10	10	10
Illinois T 19	0.93	60	--	--	40
Urbana	0.31	90	--	--	10
Pearl Harbor	0.07	100	--	--	--
Marglobe	3.72	50	20	30	--
Marglobe Supreme	2.10	30	40	30	--
Joan Moran	2.33	60	20	10	10
Grothen's Globe	1.22	60	10	10	20
Rutgers	3.60	40	50	10	--
V-13	3.01	60	20	10	10
Baladi	3.55	60	20	10	10
Pritchard	2.60	50	20	20	10
North Dakota	3.70	60	10	20	10

imported tomato varieties as well as other common varieties extensively grown in most cultivated areas of Egypt.

The mean root-knot index is a result of the visual relative amount of root galling according to the system used by Smith and Taylor (3). In this system the mean root-knot index is determined by multiplying the number of plants in each category index by their respective category number and dividing by the total number of plants examined for each variety. From Table 1 it can be seen that the mean root-knot index is only a fairly good measure of potential root damage. In this respect a mean index of 2.0 or above may be considered as representing a relatively severe attack by root-knot nematode populations. It may be noticed, then, that five of the ten imported varieties showed a relatively high root galling index. The other five showed relatively lower indexes, which is encouraging from the standpoint of breeding for resistance. The Pearl Harbor variety showed very inconspicuous galls and was almost tolerant to nematode attack. The variety Urbana also showed very few galls on the roots.

As a rule, species of root-knot nematodes differ in extent of gall formation, hence plants suffering from the same number of nematodes may be given different visual gall ratings. It was necessary, then, that in addition to the relative root-knot index, the percentage occurrence of the different root-knot species on the different tomato varieties should be determined. Species were identified according to the morphology of the perineal pattern of adult females, which was found by Chitwood (1) and Sasser (2) to be a very reliable basis for species differentiation. Results indicated that only four species of Meloidogyne are present in this locality. These four species are M. javanica (Treub, 1885) Chitwood, 1949, M. incognita (Kofoid & White, 1919) Chitwood, 1949), M. hapla Chitwood, 1949, and M. incognita var. acrita Chitwood, 1949. The percentage occurrence of these species, as shown in the table, varied with the varieties tested. Some were infected by all the species, others by one, two, or three only. It is to be noticed, however, that most of the varieties tested were attacked by most of the four species, and in particular by the Javanese root-knot nematode, M. javanica, which is the predominant species in this area. Its incidence was over 50 percent in most of the plants examined. The varieties Pearl Harbor and Urbana, in addition to the indication of resistance given by their low mean root-knot indexes, showed an extremely low number of developed mature females, almost all belonging to M. javanica. It can be seen also from the table that a sort of a correlation exists between the percentage occurrence of the species found on a given variety and the relative mean root-knot index of the variety. Thus when the roots were infected mainly with M. javanica the relative gall index was low, which was also true of M. hapla. However, when the roots were also infected with a considerable number of M. incognita and M. incognita var. acrita the root gall rate was relatively high.

Conclusions

Under the ecological conditions prevailing in this area (Giza) four species of root-knot nematodes are present, of which the Javanese nematode, Meloidogyne javanica, is the predominant species. Field tests evaluating the degree of resistance of different tomato varieties to natural root-knot populations indicated that Pearl Harbor possesses a high degree of resistance to the four species of root-knot nematodes, which commonly attack tomato roots. The fact that this variety was resistant to M. javanica, the species which causes serious damage in this area, is important. The Urbana and Illinois T 19 varieties were intermediately susceptible to M. javanica and M. hapla but tolerant to M. incognita and M. incognita var. acrita. These tomato varieties have not yet been used extensively enough in Egypt to gather more information on their value as promising varieties tolerant to nematode attack. The great variability in occurrence of the root-knot species among the various tomato varieties is very encouraging to the planning of a breeding program.

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PLANT PROTECTION DEPARTMENT, FACULTY OF AGRICULTURE, CAIRO UNIVERSITY, GIZA, EGYPT

CONTROL OF MELOIDOGYNE INCOGNITA ACRITA BY CROP ROTATIONS[1]

H. W. Crittenden[2]

SUMMARY

Research in field plots at Bethel, Delaware for the period 1952-1955, inclusive, has shown that the best rotations for control of Meloidogyne incognita acrita Chitwood, 1949, based upon the amount of root-knot on cantaloupe in 1955, are as follows: (a) Crotalaria spectabilis, Blackhawk soybean, and clean fallow in May and June followed by Monroe soybean. This represents 3 consecutive years of resistant crops. (b) Two years of Blackhawk soybean equalled the control given by the 3 years of resistant crops. (c) Crotalaria spectabilis and Monroe soybean gave essentially the same control as did the two preceding rotations.

One year of a resistant crop results in some control on a susceptible crop the next year. This degree of control may be satisfactory under some conditions.

Thus, it is concluded that best control results from the use of resistant crops for 2 consecutive years. Furthermore, the use of a cash crop such as resistant soybeans appears to be a very economical method of control.

The advantages and disadvantages of the use of crop rotations for control of root-knot nematodes have been well stated by Sasser and Nusbaum (3). Crotalaria spectabilis was the most resistant crop available in 1949, when preliminary work was started, but its popularity with the growers was not high. Therefore, a search was begun to find a resistant variety of a crop that would be readily accepted by farmers. Among those crops considered, soybeans were given particular attention. Preliminary results of the search were reported in 1952 (1). Three soybean varieties (Anderson, Monroe, and Blackhawk) appeared to have a high degree of resistance to Meloidogyne incognita acrita; Anderson was the only one of the three that was not commercially available. Meanwhile, a control method was recommended to growers that did give a marked reduction of this nematode (2). This consisted of keeping the infested soil free of all vegetation during May and June, then following with a late-planted crop such as lima bean or soybean. This method of control was incorporated in an experiment on crop rotations for control of M. incognita acrita Chitwood, 1949.

MATERIALS AND METHODS

The crop rotation experiment was located near Bethel, Delaware, in a field that, in 1951, produced very few marketable cantaloupes owing to Meloidogyne incognita acrita. This field was mapped to determine the distribution of this nematode. A large part of the field showed a uniformly heavy infestation by M. incognita acrita. The experiment, begun in 1952, consisted of 12 treatments, each replicated 6 times in a randomized block. The size of each of the individual plots was 33 1/3 x 60 feet. The varieties or species of the crop plants used, and their root-knot rating as susceptible or resistant, are given in Table 1. The rotation of these crops during the years 1952 to 1955, inclusive, is shown in Table 2. The common name of the crop plants is listed in this table, except for soybean where the variety is identified because three were used. The winter cover crops consisted of barley, rye grass, and oats. These were planted about November 1 and plowed down about April 1. All of the plots had the same winter cover crop.

The clean fallow method of control was used in several treatments. This consisted of plowing the winter cover crop in early April, then preparing the soil as for planting around May 1. During May and June the soil was kept free of all vegetation by discing three or four times. The subsequent crop was planted during the first week of July.

Cantaloupe was used as an indicator crop in 1955 because it was very susceptible to this

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[2] Assistant Professor.

Table 1. Crop plants in rotation studies at Bethel, Delaware, from 1952 to 1955, inclusive.

Crop	Variety or species	Root-knot rating
Crotalaria	spectabilis	Resistant
Soybean	Blackhawk	Resistant
Soybean	Monroe	Resistant
Soybean	Chief	Susceptible
Sudan Grass	Tift	Resistant
Field Corn	Connecticut 845	Susceptible
Sweet Corn	Golden Cross Bantam	Susceptible
Snap Bean	Topcrop	Susceptible
Sweetpotato	Porto Rico	Susceptible
Lima Bean	Fordhook 242	Susceptible
Tomato	Rutgers	Susceptible
Cantaloupe	Hale's Best No. 936	Susceptible

Table 2. Crop rotation plots at Bethel, Delaware, 1952-1955, inclusive, for control of Meloidogyne incognita acrita.

Treatment	Summer 1952	Summer 1953	Summer 1954	Summer 1955
1.	Tomato	Lima Bean	Tomato	Cantaloupe
2.	Corn	Clean Fallow Sweetpotato	Clean Fallow Blackhawk	"
3.	Crotalaria	Corn	Blackhawk	"
4.	Chief	Corn	Sudan Grass	"
5.	Corn	Tomato	Crotalaria	"
6.	Crotalaria	Blackhawk	Clean Fallow then Monroe	"
7.	Clean Fallow Sudan Grass	Tomato	Sweet Corn	"
8.	Chief	Crotalaria	Monroe	"
9.	Sudan Grass	Clean Fallow Monroe	Snap Bean Clean Fallow Snap Bean	"
10.	Lima Bean	Corn	Blackhawk	"
11.	Chief	Blackhawk	Blackhawk	"
12.	Corn	Blackhawk	Snap Bean Monroe	"

Table 3. Root-knot index and yield of cantaloupe, Bethel, Delaware, in 1955, in crop rotation plots.

Treatment	Root-knot index percent[a]	Yield (number and weight of melons)					
		6 pickings[b]		12 pickings[c]		19 pickings[d]	
		No.	Wt.	No.	Wt.	No.	Wt.
1	80	39	67	184	295	250	403
2	26	111	192	314	529	379	658
3	14	83	153	292	520	378	692
4	51	94	199	274	554	368	760
5	44	103	177	315	545	399	702
6	1	114	206	303	546	378	704
7	58	85	149	268	474	347	611
8	3	135	266	317	602	390	762
9	23	82	157	307	589	402	796
10	45	109	188	304	493	364	611
11	1	96	165	275	478	360	654
12	35	68	118	268	467	379	688
LSD at .05	14	38	74	40	92	42	119
LSD at .01	19	51	99	53	123	57	160

[a] Rating of infection by Meloidogyne incognita acrita after harvest completion.

[b] July 25 through August 1.

[c] " " through August 8.

[d] " " through August 19.

species of nematode. The harvesting of melons began July 25 and continued through 19 pickings, ending August 19. The results (Table 3) are shown as the number and weight of all melons per plot after 6, 12, and 19 pickings. This total yield figure is an average of the 6 replications and was used because whether an individual melon is or is not a cull is often variable, depending on many factors. The reason for listing the yield at three different periods during the harvest season is to show the differences that exist between treatments during the harvest season.

After fruit harvest was completed, all of the plants in the plots were dug and the roots examined for infection by M. incognita acrita. This was scored on the basis of the amount of galls present on the roots. The root-knot index (Table 3) was determined by the method described by Smith and Taylor (4).

RESULTS AND DISCUSSION

Even though the check plot (treatment No. 1) showed a moderate yield, each of the other 11 treatments had a significantly higher yield (at the .01 level) both as to number and weight of melons at the end of harvest. Each of the treatments (2 through 12) also had significantly (at the .01 level) less nematode infection than the check.

A brief statement concerning control, based upon the root-knot index for each of the treatment in the experiment, is given in the following discussion.

Treatment No. 1: The check consisted of 3 years of susceptible crops, and these crops maintained a high population of M. incognita acrita.

Treatment No. 2: The use of sweetpotato plants that were somewhat susceptible increased nematode population in the latter part of the second year.

Treatment No. 3: The use of a moderately susceptible crop, in this case field corn, between resistant crops gave good control.

Treatment No's. 4, 5, and 10: These three were basically alike in that susceptible crops were used the first 2 years followed by a resistant crop in the third year. The root-knot indices indicate some control in each of the three treatments regardless of the nature of the resistant crop.

Treatment No. 6: Three consecutive years of resistant crops gave excellent control, almost eradication of the nematode.

Treatment No. 7: A reduction of root-knot nematodes in the first year of treatment followed by two consecutive susceptible crops gave some control in the fourth year.

Treatment No's. 8 and 11: Two consecutive years of resistant crops gave the same degree of control as did 3 consecutive years of resistant crops.

Treatment No. 9: The first 2 years of resistant crops followed in the third year by a susceptible crop gave only fair control in the fourth year even though control was excellent on the third-year crop.

Treatment No. 12: The use of a highly susceptible crop, in this case snap bean, between resistant crops gave only fair control.

The differences in the number and weight of melons between treatments, excluding the check treatment, are due to many factors not all of which are directly associated with control of Meloidogyne incognita acrita. Thus excellent control of the nematode is not always directly correlated with the highest yield of melons. The evidence indicates that any treatment is of some value with regard to yield of melons under the conditions of this experiment. However, the ultimate goal is the greatest reduction of the nematode with the least sacrifice by the farmer.

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DEPARTMENT OF PLANT PATHOLOGY, DELAWARE AGRICULTURAL EXPERIMENT STATION, NEWARK, DELAWARE

CONTROL BY SOIL FUMIGATION OF ROOT-KNOT NEMATODES AFFECTING FRESH FRUIT AND CANNING TOMATOES IN CALIFORNIA

Bert Lear and Ivan J. Thomason[1]

SUMMARY

During a 3-year period, five experimental field plots were established in the major tomato-growing areas of California, utilizing various soil fumigants for control of root-knot nematodes, Meloidogyne incognita var. acrita and M. javanica. Results based on yields and root galling indicate that row-placement applications of D-D, EDB, and Nemagon are comparable to solid applications of the same chemicals. Nemagon when applied as a solid application of 0.75 gallons per acre or as a row-placement application (5-foot rows) at 0.3 gallons per acre, resulted in excellent nematode control and high yields. In some experiments solid application of Nemagon at 1.5 gallons per acre or row-placement application of 0.6 gallons per acre resulted in depression in yields. Roots also were affected, exhibiting a brownish appearance with few lateral roots. Vapam, applied by chisel, plow, or disc, was ineffective. In one experiment application through overhead irrigation sprinkler gave good nematode control.

Two root-knot nematode species, Meloidogyne incognita var. acrita and M. javanica, cause widespread damage to tomatoes in California. In the southern part of the State, where the bulk of the fresh market crop is grown, damage often is severe unless control measures are taken. In these areas, the winter crop is planted from August through October, when soil temperatures are conducive to rapid increases in root-knot nematode populations. In addition to tomato plants being grown for fruit production, many acres of plants also are grown for transplanting to northern and central California fields for the annual canning crop. The degree of nematode control required for this crop is much more exacting than that for fruit crops because of county quarantine restrictions on the movement of nematode-infected transplants.

Cost of fumigation has been the major deterrent to widespread adoption of present methods of soil fumigation for tomatoes. Because of the relatively low per acre returns from the canning crop, growers hestitate to pay the cost for an adequate treatment.

The main purpose of the tests reported here was to explore the feasibility of reducing per acre costs of control by row-placement applications of fumigants.

MATERIALS AND METHODS

The following nematocides were utilized to compare efficacies of row-placement applications and solid or broadcast applications: D-D mixture (1,3-dichloropropene and 1,2-dichloropropane), EDB (Dowfume W-85, Soilfume 83, both 83% ethylene dibromide by weight), PN-20 mixture (1.84 pounds EDB per gallon plus 5.25 pounds PN mixture), Nemagon (1,2 dibromo-3-chloropropane), and Vapam (sodium methyl dithiocarbamate). In most instances, the fumigants were applied by chisel 8 inches deep in rows 12 inches apart. The treated plots were rolled by means of a cultipack immediately following injection. Vapam was applied to plots by discing, plowing, injection, and overhead irrigation sprinkler. For the disc and plow applications, the chemical was sprayed on to the soil with nozzles mounted on the machines that worked it into the soil. The irrigation sprinklers were utilized by introducing a constant flow of the material into the line while the sprinklers were in operation. Three to 4 weeks elapsed following the treatment, before tomatoes were either direct-seeded or transplanted into the plots. Yields were obtained from each plot, usually by means of commercial pickers. Twenty-five plants usually were dug at random in each plot following harvest and each root scored 0 to 4 depending upon the degree of galling. In one experiment (Imperial County) the roots were scored 0 to 3.

[1] Assistant Nematologists, Department of Plant Nematology, University of California, Davis and Riverside, California, respectively.

Table 1. Yields of canning tomatoes and control of root-knot nematodes, Meloidogyne incognita var. acrita, by solid and row-placement applications of soil fumigants. San Joaquin County, 1953.

Treatment	Dosage (gal./acre)	Number Chisels	Percentage Control		Yields (tons/acre)	
			Solid Appl.	Row Appl.	Solid Appl.	Row Appl.
None (Check)	-	-	0	0	21.7	16.2
D-D mixture	20	solid[a]	83	-	31.5	-
D-D mixture	8	1		35		27.9
D-D mixture	8	2		69		34.8
Nemagon	2.5	solid[a]	98		28.6	
Nemagon	2	1		90		33.0
Nemagon	1	1		87		35.7
Nemagon	1	2		96		34.8
Nemagon	0.5	1		66		34.5

[a] Entire area treated with chisel spacing at 12 inches.

Table 2. Yields of tomatoes and control of root-knot nematodes, Meloidogyne javanica, by solid and row-placement applications of soil fumigants. Imperial County, 1954.

Treatment	Dosage (gal./acre)	Mean Root Scores (0-3)		Percentage Control		Mean Yields Field Boxes/Plot	
		Solid Appl.	Row Appl.	Solid Appl.	Row Appl.	Solid Appl.	Row Appl.
None (Check)	-	2.72	2.52	0	0	70.7	53.7
D-D mixture	20	1.75	-	36	-	62.1	-
D-D mixture	5.7	-	1.52	-	40	-	60.8
D-D mixture	30	1.95	-	28	-	78.1	-
D-D mixture	8.6	-	1.55	-	39	-	72.1
Dowfume W-85	6	0.52	-	81	-	73.1	-
Dowfume W-85	1.7	-	0.57	-	77	-	71.4
Dowfume W-85	9	0.75	-	72	-	82.5	-
Dowfume W-85	2.6	-	0.72	-	71	-	74.4
Nemagon	1.5	1.94	-	29	-	58.2	-
Nemagon	0.4	-	1.32	-	48	-	60.6
Nemagon	3	1.65	-	39	-	64.8	-
Nemagon	0.9	-	1.4	-	45	-	65.5
Nemagon	5	1.63	-	40	-	70.6	-
Nemagon	1.4	-	0.88	-	65	-	66.6
PN-20 Mixture	15	1.56	-	43	-	73.2	-
PN-20 Mixture	4.3	-	1.33	-	47	-	68.4
L.S.D. at 19:1		0.62	0.53			9.4	15.9
L.S.D. at 99:1		0.84	0.72			12.7	21.7

Table 3. Mean yields of canning tomatoes and root-scores from pre-planting, row-placement fumigation experiment for control of root-knot nematodes, Meloidogyne incognita var. acrita. San Joaquin County, 1954.

Treatment	Dosage (gal./acre)	Number chisels	Mean Root Score (0-4)	Control (percent)	Yields lbs./plot	Yields tons/acre
None (Check)	-	-	3.7	0	1697	21.2
D-D	20	solid[a]	3.52	5	1598	20.0
D-D	12	3	2.99	19	1660	20.7
D-D	8	2	3.18	15	1580	19.7
Dowfume W-85	6	solid[a]	0.4	89	1639	20.5
Dowfume W-85	3.6	3	0.93	75	1750	21.9
Dowfume W-85	2.4	2	0.95	74	1583	19.8
Nemagon	2.5	solid[a]	0.06	98	1352	16.9
Nemagon	1	3	0.24	94	1557	19.4
Nemagon	1	2	0.71	81	1483	18.5
Nemagon	0.5	3	1.32	64	1806	22.6
Nemagon	0.5	2	0.82	84	1638	20.5
Nemagon-DD (1-9)[b]	10	solid[a]	0.53	86	1458	17.4
L.S.D. at 19:1			1.006		320	
L.S.D. at 99:1			1.335		431	

[a] Entire plot area treated with chisel spacing at 12 inches. [b] By volume.

RESULTS

Beginning in 1953 and continuing through 1954 and 1955, five experimental field plots were established in the major tomato growing areas of California[2]. Plot locations ranged from the southern border of the State in Imperial County to Sutter County, a distance of 600 miles to the north.

1953

This plot was established on the property of George Yamauchi, Lockeford, San Joaquin County, by M. W. Allen and D. J. Raski[3]. Treatments were made in April to a sandy loam for control of M. incognita var. acrita, on a canning crop. The soil moisture at time of treat-

[2] Acknowledgements: In addition to the listed cooperating growers, the following Farm Advisors of the University of California Agricultural Extension Service aided in conducting these tests: John P. Underhill, San Joaquin County; Robert A. Kortsen, Imperial County; John H. Lindt, Jr., Sutter County; and Armen V. Sarquis, Fresno County. Applications of fumigants to some of the plots were made by experimental machines owned by Shell Development Corp. and The Dow Chemical Company with the cooperation of Mr. C. W. McBeth and Mr. Harold W. Lembright of these two companies, respectively, cooperating. Mr. N. F. Hardman of the Stauffer Chemical Co. made the Vapam applications. These three companies also furnished funds for obtaining yields on one of the plots. Additional materials also were furnished by Phillips Petroleum Company and Niagara Spray Chemical Company.

[3] Associate Nematologists, Department of Plant Nematology, University of California, Berkeley and Davis, California, respectively.

Table 4. Yields of fresh fruit tomatoes and control of root-knot nematodes, Meloidogyne incognita var. acrita, by solid and row-placement applications of soil fumigants. Fresno County, 1955.

Treatment	Dosage per Acre	Type Application	Mean Root Score (0-4)	Percentage Control	Mean Yield/Plot (lbs.)
None (Check)	-	-	3.71	0	598
Nemagon	1.5 gal.	solid[a]	0.18	95	422
Nemagon	0.75 gal.	solid[a]	0.45	89	682
Nemagon	0.6 gal.	row[b]	0.85	77	632
Nemagon	0.3 gal.	row[b]	2.03	46	718
D-D Mixture	20 gal.	solid[a]	2.33	37	805
D-D Mixture	8 gal.	row[b]	3.08	17	636
Dowfume W-85	6 gal.	solid[a]	2.53	32	669
Dowfume W-85	2.4 gal.	row[b]	2.75	26	679
Vapam	100 lbs.	disc	3.20	14	644
Vapam	50 lbs.	disc	3.30	11	586
Vapam	100 lbs.	solid[a]	3.64	2	667
Vapam	50 lbs.	solid[a]	3.54	5	628
L.S.D. at 19:1			0.87		206
L.S.D. at 99:1			1.15		276

[a] Entire plot area treated with chisel spacing at 12 inches.

[b] Two chisels per row at 12 inch spacing.

ment was 13.0 percent and the soil temperature 57° F. Three replicate plots, each 10 feet wide (2 tomato rows) and 120 feet long, were included for the row-placement applications of D-D mixture and Nemagon. Solid or broadcast applications of each fumigant were made to blocks measuring 70 x 120 feet. Yields from plots receiving row-placement applications of the fumigants were increased over the untreated checks by as much as 19.5 tons (Table 1). The best nematode control based on root scores resulted from a solid application of Nemagon at 2.5 gal./A. A row-placement application of Nemagon at 1 gal./A. applied by 2 chisels per row resulted in 96 percent control and a large increase in yield.

1954

Two plots were established, one located in Imperial County for a fresh fruit crop, the other for a canning crop in San Joaquin County.

Imperial County: The soil in the field farmed by Kodama Brothers, Seeley, was a sandy loam with a moisture equivalent of 6.7 percent. The moisture content of the soil was approximately equal to the equivalent, and the soil temperature was 95° F. at a depth of 9 inches. The air temperature was 110° F. The root-knot nematode species was M. javanica. Four replicate plots each 2 rows wide and 200 feet long were provided for each treatment. The row applications were made with 2 chisels, 12 inches apart -- 6 inches on either side of the planting row. Fumigants were injected to a depth of 11 inches in the bed and the surface sealed by a V-shaped drag. Tomatoes, variety Early Pak, were direct seeded 6 weeks after treatment. No

Table 5. Yields of tomatoes and control of root-knot nematodes, Meloidogyne javanica, by solid application of soil fumigants. Sutter County, 1955.

Treatment	Dosage per Acre	Method of Application	Mean Root Score (0-4)	Percentage Control	Yields lbs./Plot (1 picking)
None (Check)	-	-	4.0	0	54
D-D mixture	20 gal.	chisel	1.64	59	336
Soilfume 83	6 gal.	chisel	2.04	49	384
Nemagon	1.5 gal.	chisel	2.14	46	368
Nemagon	0.75 gal.	chisel	2.26	43	312
Vapam	95.6 lbs.	chisel	3.08	23	-
Vapam	53.0 lbs.	chisel	3.80	5	-
Vapam	24.2 lbs.	chisel	4.0	0	-
Vapam	69.0 lbs.	disc	4.0	0	-
Vapam	29.8 lbs.	disc	4.0	0	-
Vapam	16.2 lbs.	disc	4.0	0	-
Vapam	83.5 lbs.	plow	4.0	0	-
Vapam	40.0 lbs.	plow	4.0	0	-
Vapam	23.2 lbs.	plow	4.0	0	-

significant differences in yield occurred between plots in which fumigants were applied in the row or as solid applications (Table 2). Root scores obtained at the end of the picking season indicate all treatments were significantly better than the untreated check plots, with EDB giving the most effective control of nematodes. Row-placement applications were as effective as solid applications in reducing the amount of galling on the main lateral roots.

San Joaquin County: The plot was located on the farm of Keith Reeve, Tracy, for control of M. incognita var. acrita. The soil was a clay loam having a moisture content of 17.3 percent and soil temperature range of 62° to 65° F. The moisture equivalent was 17.3 percent. Applications were made by chisel to 4 replicate plots each 10 x 175 feet. Three weeks after treatment New Improved Pearson tomatoes were transplanted by machine into the plots. Yields obtained by commercial pickers show no significant increase in any treatment over the untreated plots (Table 3). A solid application of Nemagon at 2.5 gallons per acre resulted in a significant decrease in yield. Root scores (Table 3) show EDB and Nemagon to be the most effective in controlling root-knot nematodes.

1955

Two plots were established, one in a fresh fruit crop in Fresno County and the other in a canning crop in Sutter County.

Fresno County: This plot was established on the farm of Masao Okamura, Reedley, for control of M. incognita var. acrita on staked tomatoes grown for the fresh fruit market. The treatments were made in February to 6 replicate plots, each treatment covering an area of 10 x 132 feet. The soil was a clay loam with a pH of 6.5 and a moisture equivalent of 12.3 to 15.3 percent. Soil moisture at the 8-inch depth at time of treatment was 8.1 to 8.8 percent

with the soil temperature at 50° F. Three weeks after treatment, tomato plants (New Improved Pearson) were set by hand in all plots. Harvest of the plots was begun on July 20 and subsequent pickings made at 3- to 7-day intervals until August 23. Plots were harvested 6 to 9 times, depending upon the relative yields of the vines. Results (Table 4) show that D-D at 20 gallons per acre, solid application, produced the highest yields. Nemagon appeared to give the best nematode control based on root scores. Vapam, at the dosages used in this experiment, applied by chisel or disc, did not effectively control nematodes. Nemagon at the rate of 1.5 gallons per acre solid application, or 0.6 gallons per acre row-placement application, appears to depress tomato plants with a resulting decrease in yields. However, when the dosage was decreased to 0.75 gallons per acre solid application, or 0.3 gallons per acre row-placement application, there was no apparent depression of yields and excellent control of root-knot resulted. There was, however, a marked effect on the roots of plants grown on any plot treated with Nemagon. Roots were brown with a coarse texture and fewer lateral roots.

Sutter County: The experimental area comprised about 4 acres on property farmed by H. D. Wallace, Nicolaus, for control of M. javanica. Treatments were made in February and March to a sandy soil having a moisture equivalent of 7.7 percent and pH of 6.9. The soil temperature was 40° to 48° F. and the moisture content was 14.9 percent at the time the injection treatments were made. The soil temperature was 50° to 58° F. at the time of the plow, disc, and sprinkler applications of Vapam. The size of plot utilized for treatment by chisel applicator was 10 x 174 feet. The disc and plow applications were made to plots each 20 x 174 feet. The treated areas for the sprinkler plots each were approximately 120 x 120 feet. Six sprinkler heads were used per plot, at a spacing of 30 feet in the row with rows 60 feet apart. One month after treatment the plots were direct seeded with New Improved Pearson tomato seed. Shortly after the seedlings had emerged, a heavy wind and drifting sand caused a total loss to the seedlings. The plots were disced and transplants set the last part of April. Because of these operations, some of the transplanting did not occur exactly in the treated areas of the row-placement series. Data from row-placement application plots are not presented. Because of very poor nematode control in the Vapam-treated plots and poor stands due to competition with Bermuda grass and salt grass, no yield records were obtained from 2 of the 4 replications. One picking, however, was obtained on the other 2 replications. A 100-foot section of each plot was utilized for yield records. Data (Table 5) show D-D, Nemagon and EDB to be about equal in effectiveness in nematode control, based on yields and root scores. Vapam was ineffective except when applied by sprinkler. Applications of 84 pounds and 149 pounds resulted in 480 and 624 pounds per plot with percentage controls of 54 and 72, respectively.

DISCUSSION

The utilization of row-placement applications as a means of reducing cost is not new. Good results from row treatments for control of root-knot nematodes on cotton have been reported by Raski and Allen[4]. For the canning crop of tomatoes, where beds are not formed for planting, the marking of rows so that seeds or transplants can be placed in the band of treated soil is imperative. With increasing use of direct-seeding in the field there is some danger of losing row-placement treatments if replanting is necessary. Poor seedling stands due to adverse weather conditions and diseases may necessitate reworking the soil so that the crop may be replanted. This results in reinfesting the treated soil band.

Under the conditions of some of these experiments, dosages of Nemagon as low as 1-1/2 gallons per acre had adverse effects on tomatoes. Even though these effects were not discernible on the plants until the roots were examined, the reductions in yield with higher dosages in many cases reflects the sensitivity of tomatoes to this fumigant. Reasons are obscure for the lack of noticeable yield reduction with dosages of 2-1/2 gallons on the one plot conducted in 1953. The nature of the soil, containing a high percentage of sand, may have been the major factor. It is interesting also to note the poor control obtained from Nemagon at dosages as high as 5 gallons per acre on the plot in Imperial County. Here the extremely high soil temperatures (95° F.) may have been the limiting factor.

The value of Vapam as a field treatment for tomatoes appears doubtful. Since applications other than with the introduction of water were not effective, it would appear that the most useful role of this material would be for treatment of seed beds rather than for field application. Except for the uneven distribution of Vapam when applied by means of overhead irrigation sprinkler, this would be the most feasible method of field application.

DEPARTMENT OF PLANT NEMATOLOGY, UNIVERSITY OF CALIFORNIA, DAVIS AND RIVERSIDE, CALIFORNIA

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WATER PRESSURE INJECTOR FOR NEMATOCIDES

J. M. Good and J. R. Christie

In experiments with certain nematocides, it is often desirable to apply them to the soil under living plants such as ornamental shrubs or orchard trees. These are most efficient when applied so as to reach all parts of the root system. Often injections at a depth not easily reached by the ordinary hand injector or by the drench method of applying nematocides will be necessary. In addition, there is often need for a simple, inexpensive injector for experimental or home garden use.

The water pressure injector illustrated in Figure 1 has the basic features that allow it to be constructed from cheap, available materials. A reservoir tank of 3 1/2-quart capacity is attached to the water line. It is fitted with garden hose fittings and has a plug which can be removed so that the nematocide can be placed in the tank. When small plants are treated, a tank of 1-quart capacity will be sufficient. The reservoir tank should be constructed of heavy metal to prevent bursting when water pressure is applied. On the intake side of the tank any suitable garden hose is attached to the water supply. Attached to the outlet side of the tank is a section of transparent plastic garden hose connected in turn to the injector, which is equipped with an adapter connection for garden hose and water pipe. The injector is constructed of a 1/2-inch gate valve, 3/8 and 1/4-inch reducing bushings, and a 24-inch probe. The probe is made from 1/4-inch water pipe, pointed at one end, and with four opposing 1/16-inch outlet holes located 1 inch behind the point.

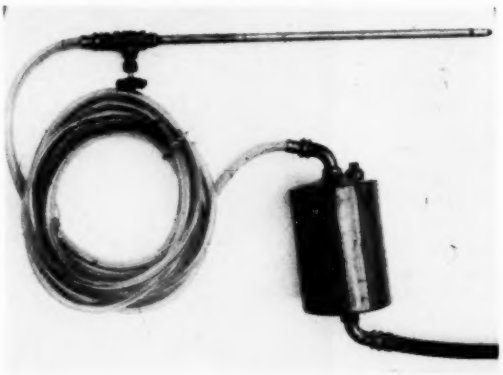

FIGURE 1. Soil injector for placement of emulsifiable nematocides by water pressure.

The operation of this type of injector is relatively simple. The desired amount of emulsifiable nematocide is placed in the reservoir tank and mixed with water. The valve is then opened slightly and the probe pushed into the soil to the desired depth. This is easily done, even in compact or heavy soils when water pressure is gradually applied. When the proper depth is reached, water pressure can be increased, though care must be taken to prevent upward channeling of the liquid along the probe. Water flow is continued until clear water can be seen flowing through the transparent hose, indicating that all the emulsified nematocide has been washed from the tank. For accuracy, only enough nematocide to treat a single injection point is placed in the tank at one time. For large shrubs or trees, it will be necessary to apply nematocide at several different injection points and depths to insure thorough treatment of the soil around the roots.

This type of probe should be adaptable to a reservoir equipped with a proportioner that will meter out the nematocide. This would allow a number of plants or sites to be treated without refilling the reservoir. An apparatus incorporating the principle outlined in this paper may be attached to any pressure water system; for example, a pressure system operated from the power take-off of a tractor. Such a system may be utilized to good advantage in orchard or grove work.

A nematocide containing 70.3% 1,2 Dibromo-3-Chloropropane has given excellent control of soil and plant-parasitic nematodes on living rose bushes and on a single fig tree when applied with the injector illustrated in Figure 1. Twenty-eight large rose bushes (variety The Doctor)

which had "coarse root" were treated. Excellent control of Pratylenchus sp., Trichodorus sp., and Rotylenchus sp. was achieved in the soil around the rose roots. The fig tree was heavily infected with root-knot nematodes (Meloidogyne spp.). An area of approximately 40 square feet was treated. The new root growth was free from root-knot nematodes, and only an occasional viable female with attached egg mass could be found in the older galls. No plant parasitic nematodes could be found in the soil surrounding the roots, and only a few free-living soil nematodes were found.

USDA NEMATOLOGY FIELD LABORATORY, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, TIFTON, GEORGIA, AND UNIVERSITY OF FLORIDA, AGRICULTURAL EXPERIMENT STATION, GAINESVILLE, FLORIDA

A PROCEDURE FOR TESTING THE STERILITY OF LARGE NUMBERS OF NEMATODES AFTER TREATMENT WITH VARIOUS STERILANTS

B. F. Lownsbery[1] and J. W. Lownsbery

In many phases of nematological research it would be desirable to use large numbers of sterile nematodes (nematodes free of their associated microorganisms). Small numbers of nematodes have been sterilized (e.g. 1,2, 5,6,7 and 8). Lots of 200 to 300 Aphelenchoides fragariae have been made almost completely sterile (3).

A satisfactory method for testing sterilants with large numbers of nematodes must minimize chances of air contamination during testing, and allow easy transfer of nematodes through solutions. The procedure described here was developed to meet these objectives.

APPARATUS

Two pyrex 60 milliliter cylindrical separatory funnels and a test tube are joined with non-absorbent cotton (Fig. 1). Dow-Corning stopcock grease is used so that the apparatus can be autoclaved. The upper separatory funnel and stems of both funnels are shortened. The stems are rebevelled to aid flow. The 1-inch diameter pyrex test tube has been shortened to a 3-inch length. Broom clamps are used to mount a number of such apparati on wooden racks. The length of the apparatus and racks can be adjusted to fit the autoclave available.

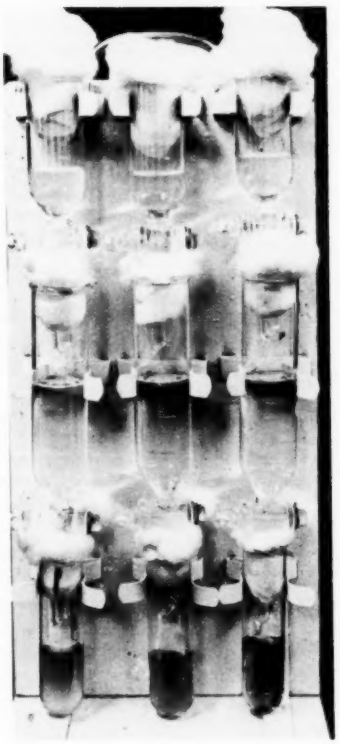

FIGURE 1. Nematode sterilant testing apparati.

USE OF APPARATUS

Fifteen milliliters of N.I.H. fluid thioglycollate broth (4) is placed in each of the test tubes. This culture medium was chosen because it will support growth of most bacteria and fungi, and will inactivate some sterilants, particularly those containing mercury (4). Forty milliliters of distilled water containing 0.01% dioctyl sodium sulphosuccinate wetting agent is added to the bottom separatory funnels. The wetting agent facilitates settling of small nematodes. The three parts of the apparatus are joined with non-absorbent cotton and autoclaved at a pressure of 15 pounds per square inch for 15 minutes.

Then the sterilant, a wetting agent, and the nematodes are added to the top separatory funnels and left for the desired time. (This must be long enough to allow the nematodes to settle to the bottom of the funnel. Approximately 90 percent of Meloidogyne larvae settle in 16 hours. Larger nematodes require less time. The fact that long treatments with dilute sterilants are usually more satisfactory than short treatments with higher concentrations (3) lessens the importance of the restriction imposed by settling time.)

At the end of the treatment period 1 milliliter is dropped to the lower funnel for the sterile water rinse. (Graduations scratched on the separatory funnels make an approximate 1 milliliter transfer possible). The nematodes are again allowed to settle. Then 1 milliter is dropped into the test tube containing the culture medium. After an incubation period of at least one week the medium is examined for growth of microorganisms.

[1] Assistant Nematologist, Department of Plant Nematology, University of California, Davis, California.

PRELIMINARY RESULTS

A suspension containing 98 percent second stage larvae of Meloidogyne incognita var. acrita, 1 percent Rotylenchus, and 1 percent Rhabditida was obtained by incubation (9) of well-washed tomato roots, using 0.1% dihydro streptomycin sulfate in the incubation water. Nematodes were concentrated and purified by centrifugation, passage through toilet tissue on a Baermann funnel, and repeated washing and centrifugation in sterile distilled water. (Early experiments had indicated low probability of success unless the starting nematode suspension was essentially free from extraneous matter.) Twelve lots of 1,000 of these larvae were treated 72 hours in the upper separatory funnel in 0.0004% ethoxyethyl mercury chloride[2] and 0.01% dioctyl sodium sulphosuccinate. Three weeks after transfer of the larvae from the lower separatory funnel to the broth, there was no growth in four tubes, growth of a Bacillus in eight.

Separate tests had shown that the dihydro streptomycin sulfate treatment, the ethoxyethyl mercury chloride treatment, and both these treatments given serially did not reduce subsequent galling of tomato roots by the treated Meloidogyne larvae.

These results indicate that it is possible to free large lots of plant parasitic nematodes from associated microorganisms. However, treatments resulting in more consistent sterility are needed.

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UNIVERSITY OF CALIFORNIA, DAVIS, CALIFORNIA

[2] Kindly supplied by R. S. Pitcher, East Malling Research Station, England.

HELMINTHOSPORIUM MAYDIS ON SWEET CORN EARS IN FLORIDA

Alice L. Robert[1]

ABSTRACT

A blackening of the silks of Ioana and Golden Security varieties of sweet corn was noted in commercial fields near Fort Myers, Florida. This disease is caused by Helminthosporium maydis. Isolation of the fungus, tests of its pathogenicity, and its identification in association with the ear disease, are described. Reference is made to effective control of the leaf blight, also caused by the fungus; in commercial sweet corn fields by spraying with zineb or nabam.

INTRODUCTION

Sweet corn market ears were found to be affected by a blackening of the silks protruding from the ears in the area of Fort Myers, Florida, in 1955. Occasionally an ear was found in which a few kernels at the tip and a portion of the husks and cob had turned black. The disease was scattered at random over an entire field and affected the Ioana variety up to as high as 25 percent in some fields. Only occasionally were blackened silks found in the Golden Security variety, also grown in this area. This condition was observed during the latter part of October and the first part of November. Earlier and later harvestings seemed to have escaped noticeable injury. There was little loss to the market crop because usually only the protruding silks were blackened. There was no further development of the condition after harvesting, precooling, and placing the corn in cold storage[2].

Ears of Ioana sweet corn affected in this manner were sent to the United States Department of Agriculture, Beltsville, Maryland, for examination (Fig. 1). These specimens had been selected from a field at least a week after the crop had been harvested and the poor development of these late ears was not necessarily attributed to the disease according to the grower.

ISOLATION AND MORPHOLOGY AND GROWTH OF THE CAUSAL FUNGUS

Examination showed the darkened areas at the tips of the ears, including silks, husks, kernels, and cobs, to have an abundance of conidia of Helminthosporium sp., resembling those produced by the southern corn leaf blight fungus Cochliobolus heterostrophus Dreschs. (Helminthosporium maydis Nisik. & Miyake) (Fig. 2). Spots on the flag leaves yielded the same fungus. Isolations were made from these affected parts of the ear and the fungus was obtained in pure culture.

Conidial measurements and septation of the Florida fungus come within the range of measurements of those of Helminthosporium maydis and H. carbonum Ullstrup races 1 and 2 (Table 1). The average length is nearer that of H. maydis as described by Nisikado and Miyake (3), although the range in length of the conidia is not so great as that observed by these two workers or by Drechsler (1) or Ullstrup (6). The conidia appear to be more curved than those of H. carbonum and they do not become so dark with age as do those of H. carbonum.

On potato-dextrose agar the cultural growth of single-conidial isolates was essentially the same as that of single-conidial isolates of two known cultures of H. maydis, and unlike the growth of single-conidial isolates of H. carbonum race 1 and of one culture of H. carbonum race 2, at eight temperatures. Comparisons of five single-conidial isolates of the Florida Helminthosporium with five each of the other isolates of Helminthosporium were made at 10°, 15°, 20°, 25°, 30°, 35°, and 40° C. Growth occurred and conidia were produced within a week's time at all temperatures except 10° and 40° C. The rate of growth of the Florida Helminthosporium on potato-dextrose agar was less than that of the other isolates at each of the temperatures tested.

On cornmeal agar, at 25° C, cultural growth of five single-conidial isolates was essentially the same as that of H. maydis cultures and different from isolates of H. carbonum.

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[1] Plant Pathologist, Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

[2] In correspondence from N. R. Rouse, United States Department of Agriculture Inspection Office, Fort Myers, Florida.

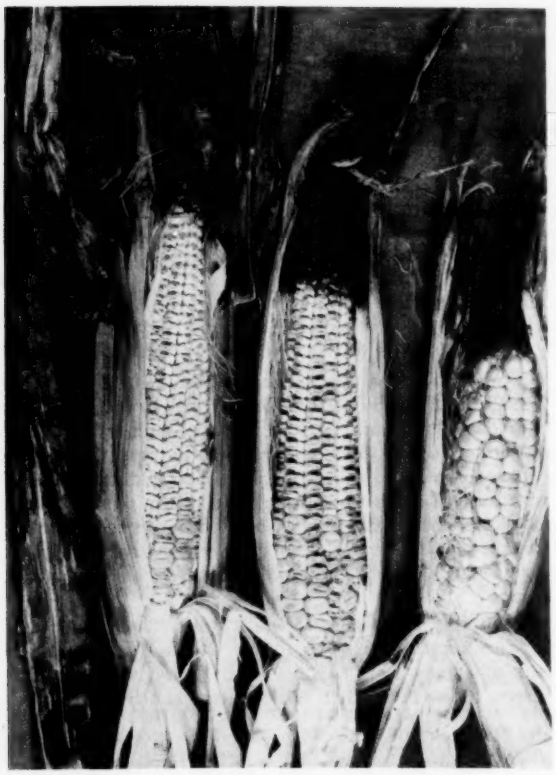

FIGURE 1. Ears of Ioana variety sweet corn from Florida showing natural infection of silks, tips of husks and ears, and flag leaves with Helminthosporium maydis.

FIGURE 2. Conidia of Helminthosporium maydis isolated from blackened tips of sweet corn ears from Florida. A X750; B X187 (approximate).

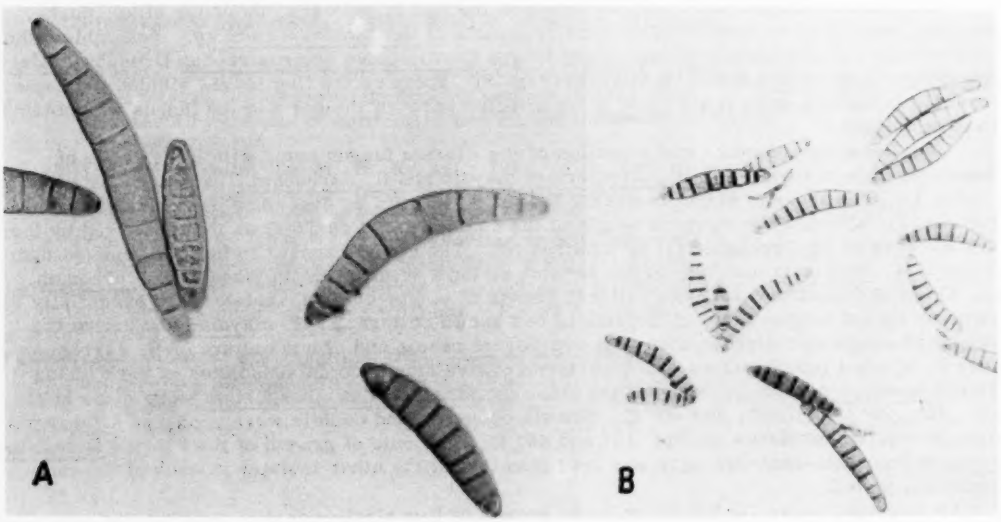

Table 1. Comparison of length, width, and number of septa, between conidia of the Helminthosporium sp. on sweet corn ears from Florida, and of H. maydis, and H. carbonum races 1 and 2, as previously described.

Helminthosporium	Conidial comparisons					
	Length in microns		Width in microns		Number of septa	
	Range	Average	Range	Average	Range	Average
H. maydis (Florida)	60.1-103.5	90.2	13.4-16.7	15.0	5 - 10	8.0
H. maydis Nisikado & Miyake (3)	30 -140	84.6	10.2-21.7	14.7	2 - 15	7.8
H. maydis Drechsler (1)	30 -115 30 -115		10.0-17.0 10.0-17.0		 - 12	
H. maydis Ullstrup (6)	24.8-127.4	89.2	10.6-21.2	14.9	3 - 13	8.3
H. carbonum race 1 Ullstrup (6)	24.8-99.1	61.2	7.1-17.7	13.0	2 - 12	6.8
H. carbonum race 2 Ullstrup (6)	24.8-102.7	64.0	10.6-17.7	13.5	3 - 12	7.2

It is concluded that the fungus causing blackened ear tips of sweet corn in Florida is essentially the same morphologically and culturally as Cochliobolus heterostrophus (Helminthosporium maydis) as described by Drechsler (1).

INOCULATION EXPERIMENTS

Young plants of corn inbred lines Mo21A, K55, and K61, grown in 4-inch pots, were inoculated in the greenhouse by spraying one pot of each line separately with a water suspension of a culture from the blackened silks, a shrunken kernel, a brown spot on the inner husk, and a spot on the flag leaf. Very heavy spotting appeared on these corn hosts with each culture used. After 3 days the spots had coalesced so as to cause wilting and dying of all of the leaves exposed to the inoculations. There were no spots or wilting of check plants sprayed only with water. Spots on inoculated leaves were light tan to buff, elongating with the length of the leaf and somewhat delimited by the veins, thus producing an angular irregular type spot characteristic of that generally caused by Helminthosporium maydis. Typical cultures of the fungus were re-isolated from spots on the inoculated leaves.

Additional inoculations were made on young corn plants with two cultures of the Florida Helminthosporium inoculated singly on each of the three inbred lines Mo21A, K55, and K61 as above. Also, at the same time cultures of H. maydis, H. carbonum race 1, and H. carbonum race 2 were inoculated singly on each of these lines for comparison. Checks of each line were sprayed with water. The plants of each inbred line inoculated with the Florida Helminthosporium were very heavily spotted with typical H. maydis lesions. Plants of the inbred lines inoculated with two isolates of H. maydis cultures from diseased corn leaves collected in North Carolina and at the Plant Industry Station, Beltsville, Maryland, also were very heavily spotted. All plants of the three inbred lines were moderately spotted by H. carbonum race 2 and plants of Mo21A and K61 were heavily spotted by H. carbonum race 1.

Plants of the sweet corn varieties Ioana and Golden Security were grown to maturity in the greenhouse. Ears of both of these varieties were poor, owing to adverse growing conditions. They were inoculated, however, with a composite inoculum made up of a water suspension of the four cultures from Florida previously used to inoculate young plants in the greenhouse. Silks of ears in the early milk stage were sprayed, husks were loosened at the tip and silks and husk sprayed, and husks were pulled down so as to expose at least some kernels and the

ear sprayed. Disturbed husks were smoothed back into place as well as possible after the inoculations. A mature leaf of each of several plants of each variety also was sprayed. Check ears and leaves were sprayed with water. All sprayed ears and leaves were covered with polyethylene bags for 3 days to maintain a high-moisture atmosphere. The bags were then removed and the ears allowed to develop until harvested 4 weeks later.

Eight ears of the Ioana variety and four of Golden Security were available for inoculation. Because of lack of pollen only two ears from each variety were self-pollinated; the remainder were pollinated with pollen from other corn plants.

All inoculated ears in both varieties had infected silks. Seven of the eight ears of Ioana variety also had darkened spots on the inner husks and three also had some shriveled and darkened kernels. Three of the four ears of Golden Security with infected silks also had darkened inner husks at the tip and a few infected kernels. One of these also had several carbon-black kernels. In moist chambers, conidiophores and conidia of H. maydis developed. The shriveled and darkened kernels bore conidiophores and conidia very heavily. Check ears were not infected in either variety and the fungus did not develop on them in moist chambers. Typical H. maydis leaf-blight lesions formed on the leaves of Ioana. On leaves of Golden Security very small, tan-colored, restricted lesions developed.

DISCUSSION

From the tests made it is concluded that the blackening of the silks and tips of ears of Ioana sweet corn from a field in Florida in 1955 was due to Cochliobolus heterostrophus (Helminthosporium maydis).

T. F. Yu, in 1933 (7), reported ears occasionally attacked by Helminthosporium maydis in fields in China. However, all infected ears showed signs of previous injury by ear worms. These were first observed in 1926. As far as known, no report of attack on ears by this fungus has been made in the United States. H. carbonum Ullstrup, races 1 and 2, attacks the ears and causes a blackening of kernels of field corn (5, 6).

Drechsler (1), in 1925, mentioned a collection of corn leaves with lesions of H. maydis obtained near Sanford, Florida, in 1923, and Brooksville, Florida, in 1917. His report is the first record of the occurrence of this disease in the United States. H. maydis now causes a serious leaf blight of corn in peninsular Florida. It is more severe in fall plantings and becomes especially heavy when humid weather makes environment more favorable for its development.

Ioana, a widely adapted hybrid in Florida, is considered to be highly susceptible to H. maydis leaf blight. Golden Security is somewhat resistant (2). It is believed that blackening of the tips of market ears is more likely when prevailing conditions favor a heavy development of H. maydis leaf blight.

CONTROL

No study of control measures for the blackening of the tips of the ears by Helminthosporium maydis was made. The control of southern corn leaf blight, also caused by this fungus, should be adequate to control the ear disease. Several workers who have made extensive studies on the control of the leaf blight recommend sanitation and rotation along with a spray schedule using nabam with zinc sulfate or zineb[3]. Timely applications of these sprays are now used effectively to control H. maydis leaf blight in commercial sweet corn fields in Florida (4).

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2. Hills, Walter A., N. C. Hayslip, J. F. Darby, and W. T. Forsee, Jr. 1953. Sweet corn production on the sandy soils of the Florida lower East Coast. Florida Agr. Exp.

[3] Nabam (disodium ethylene bis-dithiocarbamate) is sold commercially as Dithane D-14; zineb (zinc ethylene bis-dithiocarbamate) is sold as Dithane Z-78 and Parzate.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

REGIONAL SEED TREATMENT TESTS FOR THE CONTROL OF SEED-BORNE AND SOIL-BORNE COMMON SMUT OF WINTER WHEAT IN THE PACIFIC NORTHWEST FOR THE YEAR 1956[1]

Laurence H. Purdy[2]

Summary

Regional seed treatment smut control tests were made with 26 different chemical preparations, including 17 mercury derivatives, 8 hexachlorobenzene (HCB) formulations, and pentachloronitrobenzene (PCNB), 75 percent. Data were obtained from tests in 6 locations in the Pacific Northwest. The results were similar at all locations.

Good control of seed-borne smut was provided by all the materials tested. However, only the HCB and PCNB formulations controlled soil-borne smut. HCB and PCNB applied to the seed gave simultaneous control of both seed and soil-borne smut. The mercury formulations tested were only slightly effective against soil-borne smut.

Introduction

Regional seed treatment tests for the control of common bunt (Tilletia caries (D.C.) Tul. and T. foetida (Wallr.) Liro) of winter wheat began in 1954 and the first results were published in 1955[3]. Since these tests provided a wide range of environmental conditions for testing, the results were used as the main basis for regional seed treatment recommendations for wheat-smut control[4] Continued good regional performance of seed-treatment fungicides is essential to their continued recommendation. Regional tests of the type reported here provide the necessary check against the recommended materials and also provide valuable information on new formulations of immediate commercial interest.

Materials and Methods

Twenty-six chemical formulations were tested at nine locations[5] in Idaho, Montana, Oregon, Utah, and Washington. However, owing to severe winter conditions, results were obtainable from only six locations. The materials tested are listed below, along with their active ingredients reported by the manufacturers, whose names and addresses are also included.

Anticarie -- 40% hexachlorobenzene. H. D. Rossiger Company, Inc., New York, New York.

Cal. Spray 80% HCB -- 80% hexachlorobenzene. California Spray-Chemical Corp., Richmond, California.

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[1] Cooperative investigation of the U. S. Department of Agriculture, Agricultural Research Service, Field Crops Research Branch and the Agricultural Experiment Stations of Idaho, Montana, Oregon, Utah, and Washington. Scientific Paper No. 1528 Washington Agricultural Experiment Stations, Pullman, Washington.

[2] Pathologist, Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Pullman, Washington.

[3] Purdy, L. H. 1955. Regional seed treatment tests for the control of seed-borne and soil-borne common smut of winter wheat in the Pacific Northwest. Plant Dis. Reptr. 39: 844-849.

[4] Holton, C. S., and L. H. Purdy. 1956. Current recommendations on seed treatment materials used for wheat smut control in the Pacific Northwest. Washington Agricultural Experiment Station Ext. Mimeo. 1955: 1-5.

[5] Grateful acknowledgment, is extended to the cooperators at the indicated locations who assisted in these tests: Bozeman, Montana (Prof. H. E. Morris and Dr. E. R. Hehn); Kalispell, Montana (W. W. Mauritsen and V. R. Stewart); Genesse, Idaho (Lou Jain); Moscow, Idaho (Drs. A. M. Finley and K. H. Klages); Worley, Idaho (E. W. Bitters); Moro, Oregon (W. E. Hall); Pendleton, Oregon (Dr. C. R. Rohde and M. M. Oveson); Logan, Utah (Prof. D. C. Tingey); Lind, Washington (W. L. Nelson).

Ceresan D -- 2.80% ethyl mercury 2,3-dihydroxypropyl mercaptide and 0.60% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Ceresan M -- 7.7% N-(ethylmercuri)-p-toluenesulfonanilide. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Ceresan S -- 6.00% ethyl mercury 2,3-dihyroxypropyl mercaptide and 1.30% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Chipman 80% HCB -- 80% hexachlorobenzene. Chipman Chemical Company, Bound Brook, New Jersey.

Dow HCB -- 40% hexachlorobenzene. Dow Chemical Co., Midland, Michigan.

Liquid Mercury 244 -- 2.27% phenylmercury acetate and 1.57% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Liquid Mercury 365 -- 3.39% phenylmercury acetate and 2.35% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Mema -- 11.4% 2-methoxyethylmercury acetate. Chipman Chemical Co., Bound Brook, New Jersey.

Merculine 100 -- 10% phenylmercury salicylate. H. L. Woudhuysen, New York.

Mer-lin 1-37 dry -- 1.68% phenylmercury acetate and 37% gamma 1,2,3,-4,5,6-hexachlorocyclohexane. Stauffer Chemical Co., North Portland, Oregon.

Mer-sol -- 7.0% phenylmercury acetate. Stauffer Chemical Co., North Portland, Oregon.

No Bunt -- 40% hexachlorobenzene. Chipman Chemical Co., Bound Brook, New Jersey.

Panogen 15 -- 2.2% cyano (methylmercury) guanidine. Panogen, Inc., Ringwood, Illinois.

Panogen 42 -- 6.3% cyano (methylmercury) guanidine. Panogen, Inc., Ringwood, Illinois.

PMA + heptochlor -- 1.0% phenylmercury acetate and 20% 1,4,5,6,7,8,8-heptochlor-3a,4,6,6a-tetrahydro-4,7-methanoindene. California Spray-Chemical Corp., Richmond, Calif.

Puraseed -- 6.25% N-phenylmercuriformamide and 6.25% anilinocadmium lactate. Gallowhur Chemical Corp., Ossining, New York.

Sanocide -- 40% hexachlorobenzene. California Spray-Chemical Corp., Richmond, California.

Setrete -- 7.0% pehnylmercury acetate. W. A. Cleary Corp., New Jersey.

Smut B Gon -- 7.0% phenylmercury acetate. California Spray-Chemical Corp., Richmond, California.

Smut Go -- 40% hexachlorobenzene. Miller Products Co., Portland, Oregon.

Terraclor -- 75% pentachloronitrobenzene. Mathieson Chemical Corp., Baltimore, Maryland.

Velsicol Emmi (liquid) -- 10.34% 1,4,5,6,7,7-hexachloro-N-(ethylmercuri) bicyclo [2.2.1] hept 5-ene-2,3-dicarboximide. Velsicol Corp., Chicago, Illinois.

Velsicol Emmi (powder) -- 10% 1,4,5,6,7,7-hexachloro-N-(ethylmercuri) bicyclo [2.2.1] hept 5-ene-2,3-dicarboximide. Velsicol Corp., Chicago, Illinois

The Rio and Orin winter wheat varieties were used in the tests, Rio at Bozeman and Kalispell, Montana, and Orin at all other locations. Since the plots at Bozeman and Kalispell were ruined by winter killing the results reported here were all obtained with Orin.

The seed was treated in units of 250 mls by the method previously described[3]. The treated seed was planted in 3 replications of randomized 10-foot rows at each location. Smut percentages were calculated from the number of smutted heads in a sample of 200 heads from each replicate. Calculations of percentages and statistical analyses of the data were made by the Office of Tabulated Records, State College of Washington.

Statistical significance at the 5% level is indicated in the column so titled in Tables 1, 2, and 3. Treatments enclosed by an individual line do not differ significantly from each other but

Table 1. Summary of results of 6 regional tests for the control of seedborne common bunt by seed treatment in winter wheat in the Pacific Northwest, 1956.

Treatment	Form	Rate[a]	Arc Sine Mean	Percent Bunt	Statistical Significance
Check - untreated			51.885	61.8	|
Puraseed	S[b]	1/2	8.771	2.30	
Dow HCB	S	1/2	7.403	1.60	
Sanocide	S	1/2	6.800	1.40	
No Bunt	S	1/2	6.198	1.10	
Setrete	L[c]	1/2	5.997	1.00	
Captan-HCB 40-40	S	1/2	5.815	1.00	
Mema	L	1/4	5.498	0.91	
Smut B Gon	L	1/2	5.265	0.84	
Smut Go	S	1/2	4.890	0.72	
Mer-sol	L	1/2	4.679	0.66	
Anticarie	S	1/2	4.456	0.60	
Dow HCB	S	1	4.331	0.57	
PMA+Heptochlor (Cal. Spray)	L	4 1/2	3.449	0.36	
Ceresan S	L	1/2	3.243	0.32	
Merculine 100	L	1/2	3.216	0.31	
Cal. Spray 80% HCB	S	1/2	2.980	0.27	
Velsicol Emmi	S	1/2	2.974	0.26	
Panogen 42	L	0.2	2.883	0.25	
Captan-HCB 40-40	S	1	2.844	0.24	
Velsicol Emmi	L	1/2	2.497	0.18	
Mer-lin 1-37 dry	S	2 2/3	2.393	0.17	
Ceresan M	S	1/2	2.214	0.14	
Terraclor	S	1	2.192	0.14	
Ceresan D	L	3/4	2.180	0.14	
Panogen 15	L	3/4	2.066	0.12	
Chipman 80% HCB	S	1/2	1.860	0.10	
Liquid Mercury 244	L	3/4	1.676	0.08	
Sanocide	S	1	1.385	0.05	
Smut Go	S	1	1.272	0.04	
Liquid Mercury 365	L	1/2	1.229	0.04	
No Bunt	S	1	1.050	0.03	
Anticarie	S	1	0.770	0.01	|

[a] Rate in ounces per bushel.

[b] Wettable powder as a slurry.

[c] Liquid.

are significantly different from these treatments outside the limits of that line.

Results

The results from all six locations were similar and therefore analysis of data was based on the averages from these locations. Results of the tests for the control of seed-borne common bunt by seed treatment are presented in Table 1.

A high incidence of bunt developed in the check rows at all locations; the average was 61.8 percent. All treatments controlled the disease satisfactorily and there were no significant differences among the treatments (Table 1). The good performance of the phenylmercury derivatives was in contrast to their relatively poor performance in 1955[3]. Such erratic performance has been observed previously in these materials and is not readily explained.

The results of tests for the control of soil-borne bunt by seed treatment are summarized in Table 2. In these tests 43.73 percent bunt developed in the check rows where clean, smut-free seed was planted in artificially infested soil. The mercury preparations, as usual, proved ineffective against soil-borne inoculum. There was no significant difference between the checks and Panogen 15 and Velsicol Emmi. Formulations of hexachlorobenzene (HCB), pentachloronitrobenzene (PCNB), and captan plus HCB provided good protection against infec-

Table 2. Summary of results from 6 regional tests for the control of soil-borne bunt by seed treatment in winter wheat in the Pacific Northwest, 1956.

Treatment	Form	Rate[a]	Arc Sine Mean	Percent Bunt	Statistical Significance
Check - untreated			41.427	43.73	
Panogen 15	L[b]	3/4	35.941	34.40	
Panogen 15	L	1 1/2	35.341	33.40	
Velsicol Emmi	L	1/2	34.704	32.40	
Velsicol Emmi	L	1	29.238	23.80	
Cal. Spray 80% HCB	S[c]	1/2	14.140	5.90	
Terraclor	S	1	9.556	2.70	
Captan-HCB 40-40	S	1	8.488	2.10	
Cal. Spray 80% HCB	S	1	8.355	2.10	
Sanocide	S	1	8.215	2.00	
Dow HCB	S	1	7.462	1.60	
Chipman 80% HCB	S	1/2	7.389	1.60	
No Bunt	S	1	6.733	1.30	
Anticarie	S	1	6.597	1.30	
Anticarie	S	2	6.520	1.20	
Sanocide	S	2	5.696	1.00	
Captan-HCB 40-40	S	2	5.832	1.00	
Dow HCB	S	2	5.692	0.98	
Chipman 80% HCB	S	1	5.311	0.85	
No Bunt	S	2	5.297	0.85	
Terraclor	S	2	3.717	0.41	

[a] Rate in ounces per bushel.

[b] Liquid.

[c] Wettable powder as a slurry.

Table 3. Summary of results from 6 regional tests for the simultaneous control of seed- and soil-borne bunt in winter wheat in the Pacific Northwest, 1956.

Treatment	Form	Rate[a]	Arc Sine Mean	Percent Bunt	Statistical Significance
Check - untreated			58.980	73.36	
Panogen 15	L[b]	3/4	37.182	36.50	
Panogen 15	L	1 1/2	33.529	30.50	
Velsicol Emmi	L	1/2	30.934	26.40	
Velsicol Emmi	L	1	29.171	23.70	
Dow HCB	S[c]	1	12.222	4.40	
Sanocide	S	2	10.703	3.40	
No Bunt	S	1	10.694	3.40	
Chipman 80% HCB	S	1/2	10.395	3.20	
Captan-HCB 40-40	S	1	8.379	2.10	
Sanocide	S	1	7.732	1.80	
Captan-HCB 40-40	S	2	7.710	1.80	
Anticarie	S	1	7.708	1.70	
Chipman 80% HCB	S	1	7.459	1.60	
Terraclor	S	1	7.421	1.60	
Dow HCB	S	2	6.979	1.40	
Cal. Spray 80% HCB	S	1	6.919	1.40	
Cal. Spray 80% HCB	S	1/2	6.552	1.30	
Terraclor	S	2	5.629	0.96	
No Bunt	S	2	5.405	0.52	
Anticarie	S	2	4.160	0.52	

For footnotes a, b, c see Table 2.

tion by soil-borne spores. There were no significant differences between these treatments. The 40% HCB formulations at the 1-ounce rate gave good control, with only slightly better control at the 2-ounce rate. The two 80% HCB formulations performed well at the 1/2-ounce rate, giving about the same control as the 1-ounce rate of the 40% formulations. Further tests are needed for adequate evaluation of the 80% formulation.

Data obtained from tests for the simultaneous control of seed- and soil-borne smut by seed treatment are presented in Table 3. Since both the seed and soil were inoculated, higher percentages of bunt developed in the check rows than in the other two tests. Good protection against infection was provided by all of the HCB and PCNB formulations. In this test also, 80% HCB at 1/2 ounce per bushel seemed as effective as 40% HCB at the 1-ounce rate. Further tests are desirable before final conclusions can be made on this point.

The two mercurials, Panogen 15 and Velsicol Emmi, were significantly inferior to the other treatments and did not provide adequate protection against the soil-borne inoculum. These materials permitted similar smut development in the tests against soil-borne inoculum alone and against the combined seed-borne and soil-borne inoculum (Tables 2 and 3). It is evident that mercury treatments are effective against seed-borne spores but do not protect against infection by soil-borne spores.

UNITED STATES DEPARTMENTOF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, AND AGRICULTURAL EXPERIMENT STATIONS OF IDAHO, MONTANA, OREGON, UTAH, AND WASHINGTON

COTTON SEED PRODUCED IN SOUTH CAROLINA IN 1954 AND 1955, ITS VIABILITY AND INFESTATION BY FUNGI[1]

C. H. Arndt

SUMMARY

Cotton seed produced in South Carolina in 1954 was generally not infested or only lightly infested by mycelia of the anthracnose fungus (Colletotrichum gossypii). In contrast, the seed produced in the Coastal Plain and southern Piedmont in 1955 was heavily infested, as was indicated by the high percentage of the seedlings infected by this fungus. Most seed produced in the northern Piedmont in 1955 was lightly infested. The data presented indicate that the degree of infestation was directly related to the amount and frequency of rainfall at the time of boll opening, and that this same association of rainfall with boll opening had an adverse effect on seed viability.

Cotton seed produced in South Carolina is generally heavily infested by the anthracnose fungus, Colletotrichum gossypii. In contrast, to the usual heavy infestation, the degree of infestation was relatively low after the dry summer of 1954. This was indicated by the fact that only 2 samples of seed, of the 60 samples germinated, had more than 50 percent of the resulting seedlings infected by this fungus. Both of these samples were obtained in the Coastal Plain south of the Santee River. The seedlings from other samples obtained from this same area generally showed from 30 to 40 percent infection by the anthracnose fungus. Only two other samples, one from the Coastal Plain north of the Santee River and the other from the Piedmont, showed as high as 30 percent infection of the seedlings. The viability of the seed of all samples was generally good, as was indicated by a mean seedling emergence in steamed sand culture of 84 percent and a range of 70 to 92 percent.

Because of this unusually low incidence of infestation of cotton seed by the anthracnose fungus in 1954, representative samples of cotton seed that were being reserved by growers for planting were collected in November 1955. Seeds from samples collected in both 1954 and 1955 were grown in steamed sand for 2 weeks at 25° C. This method of ascertaining seed viability tends to give somewhat lower values than the standard paper towel method, but it serves as a better index of seed vitality and provides ample time for any infesting pathogens to infect and produce lesions on the seedlings (1). The seedlings that did not show lesions after this growth period constitute the healthy seedlings of Table 1. Material from the lesions was examined microscopically to identify the infecting fungi, although it is generally possible to identify anthracnose lesions by their distinctive linear shape. This fungus was present in such a large proportion of the lesions that the differences in the percentages of emerged and healthy seedlings in Table 1 give a relatively accurate indication of the number of seedlings infected by the anthracnose fungus.

SEEDLING EMERGENCE FOR SEED COLLECTED IN 1955

The lowest mean emergence, 46 percent, was obtained for the 10 samples of seed from the north Coastal Plain (Table 1). The highest emergence for these samples was 76 percent, and for only four samples was it greater than 60 percent. The mean emergence for seed from this area probably would have been even lower if all samples collected east of a line connecting the towns of Sumter and Bennettsville had been germinated. After emergences of 34, 7, 5, 32, and 58 percent had been obtained for five samples from this area, the other samples collected were not germinated, since it was evident that the viability of the seed was so low that it was not satisfactory for planting. The mean emergence of the samples collected from the Coastal Plain south of the Santee River, 47 percent, was essentially the same as that for those collected north of the river, but none of the samples had viability lower than 24 percent. The mean emergence for the samples from the northern Piedmont, 79 percent, was slightly higher than for those from the southern Piedmont, 67 percent, and much higher than those from the Coastal Plain.

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[1] Technical Contribution No. 258 of the South Carolina Agricultural Experiment Station, Clemson, South Carolina.

Table 1. Emergence and infestation by pathogenic fungi of cotton seed produced in South Carolina in 1955, as indicated by seedling emergence and seedling infection by three pathogens.

Section	No. of samples	Seedlings/100 seeds				No. of samples in which the fungus stated was present		
		Total		Healthy				
		mean	range	mean	range	Cg[e]	Fspp[f]	RSg
Northern Piedmont[a]	25	79	72-89	44	11-67	24	20	0
Southern Piedmont[b]	6	67	46-88	18	1-54	6	2	2
North Coastal Plain[c]	10	46	5-76	16	0-30	7	5	4
South Coastal Plain[d]	19	47	24-76	19	0-54	18	15	9

[a] Anderson, Oconee, and Chester Counties.

[b] Aiken, Edgefield, and Saluda Counties.

[c] Coastal Plain north of Santee River.

[d] Coastal Plain south of Santee River.

[e] Colletotrichum gossypii.

[f] Fusarium spp.

[g] Rhizoctonia solani.

Table 2. Comparative rainfall in the Coastal Plain and Piedmont divisions of South Carolina during the months of August and September in 1954 and 1955, and the normal rainfall for the same areas[a].

Month	Coastal Plain					Piedmont				
	Rainfall (inches)			No. of days with 0.1 inch or more		Rainfall (inches)			No. of days with 0.1 inch or more	
	Normal	1954	1955	1954	1955	Normal	1954	1955	1954	1955
August	5.70	2.58	4.64	3.6	7.3	5.41	2.39	4.07	4.1	6.8
September	4.53	2.54	8.18	4.1	9.3	3.64	0.58	1.93	1.2	3.3

[a] From data of the United States Department of Commerce, Weather Bureau, Climatological Data, South Carolina Annual Summary 1954, Vol. 57, No. 13, and Annual Summary 1955, Vol. 58, No. 13, Coastal Plain and Piedmont as used are largely coextensive with the Eastern and Western divisions respectively of the Climatological Data.

46 and 47 percent. The emergence for the best samples from the northern and southern Piedmont was about the same, 89 and 88 percent, respectively, (Table 1).

FUNGI INFESTING THE SEED

All of the 60 samples tested, except three from the northern Coastal Plain and one sample each from the southern Coastal Plain and northern Piedmont, were infested by the anthracnose fungus (Table 1). The relative number of all seedlings infected by this fungus was largest for the six samples from the southern Piedmont. One of the latter samples showed an emergence of 88 percent, but had only 1 percent of uninfected seedlings after 2 weeks. The samples from the northern Piedmont had the least number of seedlings infected by the anthracnose fungus

and one of these samples had the highest percentage, 67 percent, of healthy seedlings.

Rhizoctonia solani was obtained from the seeds of 15 of the 60 samples collected (Table 1). The degree of infestation, however, was somewhat less than this number would indicate, since this fungus was not present on more than 1 or 2 seeds of the 100 planted for each sample. A small number of infested seeds, however, might be an important source of inoculum in the field because of the rapid growth of this fungus in the soil. All samples infested by Rhizoctonia, except one, were produced in the Coastal Plain, in which there was 12.82 inches of rainfall in August and September in contrast to 6.0 inches in the Piedmont.

Other than C. gossypii, the fungi isolated most frequently from infected seedlings were two Fusarium spp., F. roseum (Lk.) emend. Hansen & Snyder and F. moniliforme Sheldon. In the Coastal Plain, it was largely the former species. An unusual characteristic of a number of the 1954 samples from the Coastal Plain was the infection of up to 10 percent of the seedlings by this same Fusarium species. When this pathogen was the only fungus present in the lesions, the lesions were confined largely to the cortex and in most instances they were not sufficiently extensive to indicate that the seedlings were likely to be killed. The cortex was extensively rotted before there was noticeable injury to the stele and wilting of the seedling. The initial lesions increased in size more slowly than those produced by the more usual pathogens of the cotton seedlings, C. gossypii, R. solani, and Pythium ultimum Trow. Seedling infection by this species of Fusarium had rarely been observed previously by the writer. It is uncertain whether this infection was a peculiar characteristic of the 1954 seed or whether this type of infection had been overlooked previously because of its usual association with the more virulent anthracnose fungus.

Although F. roseum was found frequently in the 1955 samples from the Coastal Plain F. moniliforme was obtained from only 5 of the 29 samples. The relative abundance was reversed in the samples collected in two counties of the northern Piedmont, Anderson and Oconee, in which F. moniliforme, usually in association with C. gossypii, was found in lesions on the seedlings derived from 12 of the 13 samples. The localized distribution of these two fungi in 1955 seems to have been a characteristic of the seed of this year, since similar studies in previous years did not show this type of distribution. F. moniliforme is generally present on all seed from southeastern United States (3).

RAINFALL, SEED VIABILITY, AND INFESTATION BY FUNGI

The climatological data for the summer of 1954 show that the high viability of the seed and the absence of heavy infestation of the seed by the anthracnose fungus were associated with abnormally low rainfall (Table 2). During August and September in the Coastal Plain, the total rainfall was 45 and 56 percent, respectively, of normal, while in the Piedmont it was 44 and 16 percent, respectively. The greatest number of days in one month with appreciable rainfall was 4.1. A map included in the annual summary of the Climatological data for South Carolina in 1954 (4) shows that this same relatively low rainfall prevailed throughout the entire fruiting period of cotton, from June through September. These data do not indicate why the seed produced in the eastern portion of the cotton producing area south of the Santee River was more heavily infested by the anthracnose fungus than the seed produced west of this area. It was evident, however, from their size and vegetative vigor, that the plants in the area from which heavily infested seed was obtained had a more nearly adequate water supply than plants in areas from which lightly infested seed was obtained.

In interpreting the data of 1955 in relation to the effect of rainfall on seed viability and infestation by the anthracnose fungus, it is necessary to take into consideration the time of boll maturity, since prolonged rainy weather at the time of boll dehiscence may delay the complete opening of the bolls and the drying of the seedcotton. As long as the latter retains a high moisture content, it provides an excellent medium for the growth of fungi that may invade the seeds and lint (2). In the Coastal Plain boll opening occurred largely during the last half of August and early September. Hence, rainfall during this period might be expected to have had an adverse effect on cotton seed. This was confirmed by the association of low viability and high infestation by the anthracnose fungus of the seed produced in the Coastal Plain in 1955 (Table 1), with rainfalls in August and September of 4.64 and 8.18 inches, respectively (Table 2). In the northern portion of the Coastal Plain rainfall occurred almost daily during the first 10 days of September, or at a time when a large proportion of the cotton bolls were either fully or partially open. In the Piedmont, where most of the bolls opened after September 1 and from which area the seed viability was high, the rainfall in August 1955 was almost as great as in the Coastal Plain; but in September it was only 1.93 inches, or 23 percent of that in the Coastal

Plain. The mean number of days with rainfall in August and September were 6.8 and 3.3, respectively (Table 2). In the Piedmont area, the seed of lowest viability and the most heavily infested seed came from southeastern Saluda County, in which the rainfall was only slightly greater than for the Piedmont as a whole, but the bolls in this area began to open during the period of frequent rainfall in late August.

These observations support the previous deductions of Miller (3) to the effect that high atmospheric humidity and, by inference, abundant rainfall are favorable for the growth of the anthracnose fungus on various parts of the cotton plant and for the subsequent production of the spores that infest the seed.

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SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, CLEMSON

EVALUATION OF SALT, NaCl, AS A PROTECTANT AND CHEMOTHERAPEUTANT AGAINST THE DUTCH ELM DISEASE FUNGUS IN AMERICAN ELM TREES

Arthur W. Engelhard[1]

ABSTRACT

Salt, NaCl, was evaluated as a protectant and chemotherapeutant on 619 American elm trees (Ulmus americana L.) against Dutch elm disease (Ceratostomella ulmi Buisman). The trees were growing in rows in the Natural History Survey Experimental Tree Disease Plot at Urbana, Illinois. They were 7 years old, 8 to 12 feet in height and averaged 1 1/2 inches in diameter at the base.

Salt was applied in aqueous solution on each side of the rows at the rate of 1/2 pound per inch of basal trunk diameter. It was applied to some trees on May 24 (Salt I) and to others on June 7, 1956 (Salt II). Trees were inoculated in two groups, those of the first group (Inoculation I) in the evening of May 31 and again in the morning of June 1, and those of the second group (Inoculation II) in the evening of July 6 and again in the morning of July 7, 1956. Three hundred seven trees were in the first group and 158 in the second group. All inoculated trees, whether they received salt 1 week prior to inoculation or 1, 4, or 6 weeks after inoculation, wilted. No uninoculated trees wilted. Salt-excess injury was present on the leaves of some of the trees.

INTRODUCTION

Among many materials used in nutritional studies on American elms at the Natural History Survey has been common salt, NaCl. These studies indicated that trees which received applications of this chemical appeared to be less susceptible to Dutch elm disease than were trees not treated with salt.

Because of this observation, and because there has been considerable public interest in the use of salt in sublethal doses in attempts to control "elm disease,"[2] further exploration of the subject was undertaken. This paper reports on field experiments where salt was evaluated as a protectant and chemotherapeutant against the Dutch elm disease fungus (Ceratostomella ulmi Buisman) in American elm trees (Ulmus americana L.).

APPLICATION OF THE SALT

Agricultural grade of salt, NaCl, was applied in aqueous solution to American elm trees planted in rows, averaging about 26 trees per row, in the Natural History Survey Experimental Tree Disease Plot at Urbana, Illinois. The trees were seven years old, 8 to 12 feet in height and averaged 1 1/2 inches in diameter at the base. Sixteen rows of trees received salt and eight rows of trees received no salt. Buffer rows separated salt-treated from non-salt-treated rows.

Salt was applied at the rate of 1/2 pound[3] per inch of trunk diameter. In order to determine the quantity of salt to apply to each row, the average number of trees plus spaces where trees were missing was determined. This was done because every space as well as every tree would receive salt when it was applied in aqueous form. Each row contained an average of 37.2 trees and spaces. As the average diameter of trees was 1 1/2 inches and as salt was to be applied at the rate of 1/2 pound per inch of trunk diameter, 28 pounds of salt were allotted to each row of trees.

A 200-gallon capacity John Bean sprayer was used to apply the salt. By operating the

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[1] Present address: Experimental Station, Agricultural Chemical Section, E. I. du Pont de Nemours Wilmington, Delaware.

[2] In areas where both the virus disease phloem necrosis and Dutch elm disease are present, the two maladies are sometimes referred to collectively as "elm disease".

[3] According to experimental data kindly supplied by Dr. J. C. Carter, leaf injury occurs when NaCl is applied at the rate of 1 pound or more per inch of trunk diameter to trees similar in size to the ones used in this work.

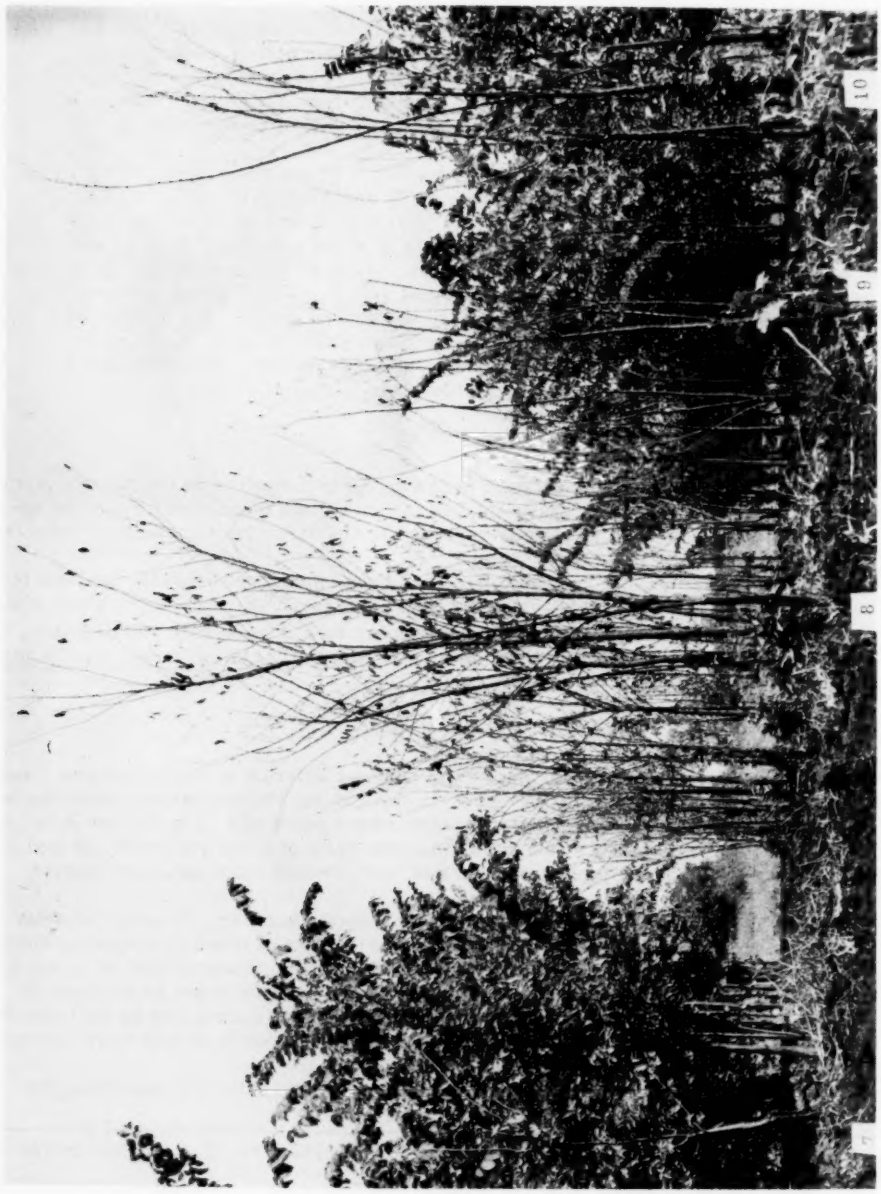

FIGURE 1. Results of salt treatment on American elms. Trees in rows 7, 8, 9 and 10 were treated with salt on June 7, 1956. Trees in rows 9 and 10 were inoculated with Ceratostomella ulmi on May 31 and June 1. Trees in row 8 were inoculated with C. ulmi on July 6 and 7. Trees were photographed on August 30, 1956.

August 30, 1956.

FIGURE 2. Dead, dying and living American elm trees in the Natural History Survey Experimental Tree Disease Plot at Urbana, Illinois, on August 30, 1956. Trees in rows 2, 3, 4 and 5 received no salt, trees in rows 7, 8, 9 and 10 received salt on June 7, and trees in rows 12, 13, 14 and 15 received salt on May 24. Trees in rows 4, 5, 9, 10, 14 and 15 were inoculated May 31 and June 1; trees in rows 3, 8 and 13 were inoculated on July 6 and 7; trees in rows 2, 7 and 12 were left uninoculated. Trees in rows 6 and 11 were untreated, separating the rows of trees receiving salt from those receiving no salt.

FIGURE 3.
Leaf damage from NaCl developed as marginal necrosis.

sprayer pump at full throttle and pulling the sprayer at the slowest speed possible without stalling the tractor, it was found that 50 gallons of water were needed to spray the ground on both sides of each of two rows. As 56 pounds of salt, the amount required to treat two rows, would easily dissolve and stay in solution in 50 gallons of water, this method was found to be convenient for applying the compound.

The salt solution was sprayed out of the opening at the front of the sprayer about 6 inches above the ground. The solution formed a V-shaped spray and covered the ground in a strip about 18 inches wide; it tended to accumulate in the track adjacent to the trees made by the wheels of the tractor and sprayed in the freshly worked ground.

Salt was applied to one group of trees on May 24, 1956 (Salt I), and to another on June 7, 1956 (Salt II).

INOCULATIONS

Trees were inoculated at different periods. Inoculation I was made on one group of trees in the evening of May 31 and morning of June 1, 1956. Inoculation II was made on a second group of trees in the evening of July 6 and morning of July 7, 1956. Each tree was inoculated in the evening and the following morning. In the evening two wounds were made on each elm with a 1/4-inch chisel within 6 inches of the ground. Each wound penetrated through at least one annual wood ring. A plastic bottle fitted with a glass tube was used to squirt a few drops of spore suspension in each wound. The following morning two similar wounds were made on each of the major stems or branches at a height of 4 to 5 feet from the ground, and a few drops of the same spore suspension were squirted in the wounds. The same procedure was followed when Inoculation II was made.

The spore suspension used for Inoculation I was prepared from four different isolates of

Table 1. Results of inoculation of American elm trees with Ceratostomella ulmi; some trees treated with NaCl. The dates of inoculation in Group I were May 31 and June 1 and the the dates of inoculation in Group II were July 6 and 7.

Treatment	Group I				Group II			
	Inoculated		Uninoculated		Inoculated		Uninoculated	
	Number of trees	Number wilted	Number of trees	Number wilted	Number of trees	Number wilted	Number of trees	Number wilted
Salt I (5-24-56)	99	99	111	0	60	60	51	0
Salt II (6-7-56)	107	107	95	0	48	48	47	0
No Salt	101	101	106	0	50	50	56	0

C. ulmi. Two of the isolates were at least 2 years old and the other two were about 5 weeks old. The colonies used to make the spore suspensions ranged in age from 3 to 31 days. Distilled water was added to the cultures two to three times. Each time water was added a flat rubber eraser was passed over the fungus colonies to help dislodge spores. Seven hundred ml. of spore suspension were prepared in this manner. With an Improved Neubauer Levy Corpuscle Counting Chamber, the spore suspension was calculated to have 59,800 spores/cmm. The spore suspension used for Inoculation II was prepared in a similar manner except that four other isolates were used in addition to the ones used for preparing the first spore suspension. The new isolates were all less than 6 weeks old. The colonies used to make the spore suspension ranged in age from 4 to 67 days. Six hundred ml. of spore suspension containing 76,650 spores/cmm. were prepared. Both spore suspensions were prepared in the afternoon and used in the evening and following morning. The portion used in the morning was refrigerated overnight.

Twelve rows of trees were divided into three groups of four rows each. The first two rows of trees in each group were inoculated May 31 and June 1 (Inoculation I) and the other two rows were not inoculated. Of the two uninoculated rows in each group, one was later inoculated on July 6 and July 7 (Inoculation II). Trees in the first group of rows received Salt I treatment on May 24, trees in the second group received Salt II treatment on June 7, and trees in the third group received No Salt. The experiment was replicated twice.

Of the 619 elm trees in the experiment, 307 were used for Inoculation I and 158 for Inoculation II.

RESULTS

All inoculated trees, regardless of whether they received Salt I, Salt II or No Salt, wilted (Table I). Whether they were inoculated 1 week prior to the application of salt or 1, 4, or 6 weeks after salt was applied did not influence the severity of wilt symptoms. By August 30, 1956, only a few scattered green leaves remained on the trees (Figs. 1, 2). Trunk sprouts or "feathering" on the lower parts of the trunks of the dying trees were common, but most of these sprouts soon wilted. Brown streaking, typical of Dutch elm disease, was present in the xylem of the wilting trees.

All but 2 of the 307 elm trees inoculated in the first group (Inoculation I) were wilting within 15 days. The remaining 2 trees were reinoculated on July 7, and they soon wilted. All 158 trees inoculated in the second group (Inoculation II) were wilting within 18 days.

Specimens for isolation tests were obtained from the first and eleventh trees in each row of trees inoculated. The Dutch elm disease fungus was obtained from every tree tested. None of the uninoculated trees wilted.

Salt-excess injury was present on the leaves of some of the trees (Fig. 3). The leaf damage resembled scorch injury in that marginal necrosis was present. Extreme salt-excess injury and death occurred on leaves that came in direct contact with the salt solution.

ILLINOIS NATURAL HISTORY SURVEY, URBANA, ILLINOIS

INFLUENCE OF TIME OF YEAR AND TYPE OF INOCULUM ON INFECTION OF OAK TREES INOCULATED WITH THE OAK WILT FUNGUS[1]

Arthur W. Engelhard[2]

Abstract

Healthy oak trees were wound-inoculated at 4- to 5-week intervals from February 1, 1953 to January 1, 1954 and on May 20, 1954 with Endoconidiophora fagacearum Bretz, the cause of oak wilt. Petri dish cultures of isolate PKR 10, "B" strain, fragments of oak wilt fungus mats and pads, and "ascospore droplets" were used for inoculum. Infection of oaks occurred only on trees inoculated during the period April 25 to August 28, 1953 with Petri dish cultures and on trees inoculated during May and August of 1953 and May of 1954 with inoculum containing ascospores.

INTRODUCTION

In order for successful long distance transmission of a pathogen to occur and infection to take place, certain conditions must be met. Some of these are: the pathogen must be available and viable, a suitable infection court must be present, and inoculation must occur during a period when conditions are suitable for infection to take place. Studies were initiated 1) to determine if mature healthy oak trees are susceptible through wounds to infection by Endoconidiophora fagacearum Bretz at each month of the year, 2) to determine how effective the inoculum present in nature throughout the year is in inciting wilt in healthy oak trees, and 3) to gain insight into conditions affecting the process of infection of healthy oaks in nature.

Inoculation studies have shown the effects of spore concentration, seasonal development of the host (4, 6), and place of inoculation on incubation period and oak wilt symptom expression (6). Roots of northern pin oaks inoculated with 65,000,000 conidia per tree developed widespread incipient wilt within 3 weeks regardless of the date of inoculation for the period May 23 through September 6. Also, trees inoculated on a low lateral branch and others inoculated on terminals developed incipient wilt within 3 weeks. The incubation periods increased as spore loads used for inoculation decreased (6).

The length of time from inoculation of mature oaks to oak wilt symptom expression varies from 11 to 60 days. The length of the incubation period is influenced by age of the spores (young spores provide more rapid infection), concentration of spores in the inoculum, method of inoculation, seasonal development of the host, and species of the host. Oak wilt symptoms appear more rapidly on trees receiving heavy loads of inoculum (5,000,000 conidia per tree) but successful inoculations are obtained with as few as 50 conidia per tree (4). Incubation periods of 10 to 60 days in the greenhouse and in the field resulted when either conidia or mycelium were used as inoculum (5) and 10 to 20 days when greenhouse seedlings were inoculated with mycelium and conidia placed in a wound or injected with a hypodermic syringe (9).

METHODS AND MATERIALS

After observing evidence of insect, rodent, and bird feeding on mats and pads formed by E. fagacearum between the xylem and phloem of wilt-killed oaks, it was reasoned that parts of these fungus structures would be the inoculum most likely to be transmitted by vectors; therefore, mats and pads (without ascospores) constituted one type of inoculum.

Since the condition of mats and pads available all 12 months of the year varies from frozen

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[2] Present address: Experimental Station, Agricultural Chemicals Section, E. I. DuPont de Nemours and Company, Wilmington 98, Delaware. Grateful acknowledgement is expressed to Dr. W. H. Bragonier for the photographs and to Drs. Bragonier and J. C. Carter for helpful criticisms on the manuscript.

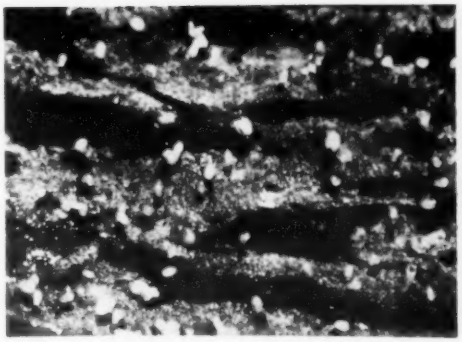

FIGURE 1.
"Ascospore droplets" exuding from perithecia on an oak wilt fungus mat.

FIGURE 2.
Slanting wounds of the type used for inoculating with laboratory cultures and with fragments of mats and pads. The wound at the left has been nailed shut.

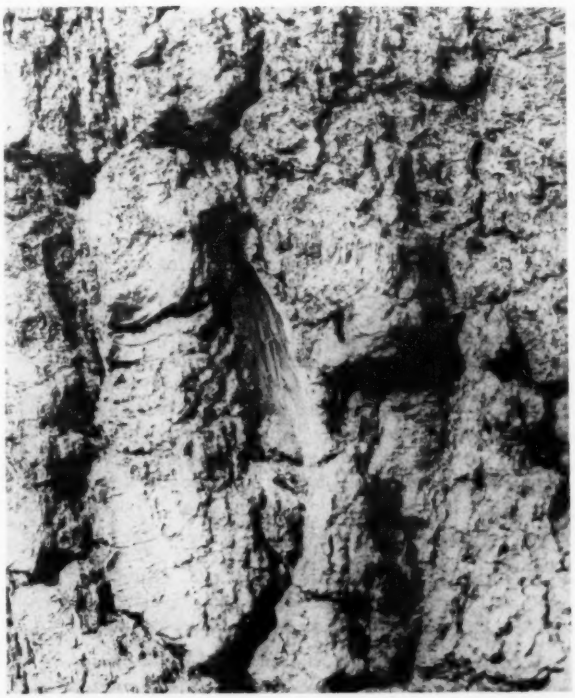

FIGURE 3.
Vertical knife-wound of type used for inoculating with "ascospore droplets".

Table 1. Number of oak trees (Quercus spp.) infected and number of oak trees not infected when inoculated with Endoconidiophora fagacearum Bretz in Pilot Knob State Park, Hancock County, Iowa, 1953-1954.

Date Inoculation	Type of Inoculum Used							
	Fragments of mats and pads [a]		Laboratory culture PKR 10		"Ascospore droplets" from perithecia [a]		Uninoculated controls	
	Trees treated	Trees killed	Trees treated	Trees killed	Trees treated	Trees killed	Trees treated	Trees killed
2-1-53	5	0	5	0	0	0	4	0
3-1-53	4	0	4	0	0	0	4	0
3-28-53	4	0	4	0	0	0	4	0
4-25-53	4	0	4	1	0	0	4	0
5-30-53	4	2 [b]	4	2	9	8 [c]	4	0
7-3-53	4	0	4	3	0	0	4	0
7-31-53	4	0	4	4	0	0	4	0
8-28-53	4	2 [b]	4	4	0	0	4	0
10-3-53	4	0	4	0	0	0	4	0
10-31-53	4	0	4	0	0	0	4	0
12-5-53	4	0	4	0	0	0	4	0
1-9-54	4	0	4	0	0	0	4	0
5-20-54	0	0	0	0	4	4	4	0
Totals	49	4	49	14	13	12	52	0

[a] From diseased trees in the park.

[b] Perithecia containing ascospores were present on the mats.

[c] Inoculated May 26, 1953. One of the trees killed was a bur oak 12 inches d. b. h.

in the winter, fresh in August-November and April-June, to dry and decomposed in the summer, a more uniform type of inoculum was desired. Use of Petri dish cultures provided this inoculum.

In May 1953, when ascospores on oaks were found for the first time in nature in Iowa, additional plots were established using this form of inoculum.

Between February 1, 1953 and January 9, 1954, 49 trees of the red oak group in Pilot Knob State Park in Hancock County in northern Iowa were inoculated with Petri dish cultures of isolate PKR 10, "B" strain. Each tree was inoculated with one-half of a Petri dish culture of the fungus. Plots of four or five trees each were inoculated at 4- to 5-week intervals during the 12 months (Table 1). Ascospores were not present in these cultures as both "A" and "B" strains are required for their formation (3).

Twelve additional plots, each identical in number of trees and each inoculated at the same times as the above, were established. The trees on the two plots established May 30 and August 28, 1953 were inoculated with fragments of fungus mats and pads which contained perithecia and ascospores. Trees on the other ten plots were inoculated with fragments of mats and pads on which no perithecia were apparent (Table 1).

On May 30, 1953, eight trees of the red oak group and one bur oak (Quercus macrocarpa Michx.) and on May 20, 1954, four members of the red oak group were inoculated with "ascospore droplets"[3] (Fig. 1) taken from fungus mats on nearby wilt-killed oaks.

The trees used in these studies ranged in size from 5 to 27 inches d. b. h. and each was more than 50 feet beyond any dead or wilting oaks.

A slanting wound made with a sterilized axe was used as an infection court on all trees inoculated with Petri dish cultures of the fungus and with fragments of mats and pads (Fig. 2). The axe cut, made on the west side of the bole at a height of 3 feet, penetrated at least 1/2 inch into the xylem. It was opened gently to permit placing the inoculum between the bark and xylem and in the cut xylem. The bark was then pushed back in place and nailed shut with two or three 1 1/2 inch aluminum nails.

Vertical knife wounds 1 inch long and 1/8 inch wide, penetrating slightly into the xylem (Fig. 3), were used for inoculating with ascospore droplets. Five to ten droplets, picked from the ostioles of perithecia found on neighboring trees, were placed in the wounds which were then covered with a small wad of moist tissue paper.

Four oaks were selected as controls on each of the dates plots were established (Table 1). Three of these were axe-wounded as previously described and one was left undisturbed. The wounds were nailed shut with two or three 1-1/2-inch aluminum nails.

RESULTS

Fourteen trees in five plots inoculated with Petri dish cultures of E. fagacearum at monthly intervals between April 25, 1953 and August 28, 1953 developed typical oak wilt symptoms (Table 1). Incubation periods for 11 of the 14 trees ranged from 3 to 9 weeks. The symptoms on the other three, if present, were masked by fall coloration. The three exhibited symptoms the following spring.

All 41 trees inoculated with fragments of fungus mat and pad material (containing no ascospores) between February 1, 1953 and January 9, 1954 remained healthy (Table 1).

Sixteen of 21 trees on four plots which received inoculum containing ascospores taken from fungus mats displayed typical oak wilt symptoms (Table 1). Fourteen of these trees had an incubation period of 3 weeks. The other two, both inoculated May 30, had incubation periods of 7 and 13 weeks.

Final observations on the plots were made by August 8, 1954. Fungus mats and pads were observed on all trees that became infected during 1953.

No control trees on any of the plots developed oak wilt symptoms.

DISCUSSION

The results obtained in these experiments indicated that ascospores constitute an effective inoculum, that periods exist during the year when trees are more readily infected than at other times, and that fragments of fungus mats and pads (without perithecia and ascospores)

[3] "Ascospore droplets" are the viscous water-insoluble masses in which ascospores are extruded from the perithecia.

are poor inoculum.

In addition to the type of inoculum and date of inoculation, other factors exist which may affect the number of inoculated trees that develop oak wilt. Temperature, precipitation, physiological condition of the host at the time of inoculation, and the competitive activity of other fungi on the mats and pads are such factors.

Of interest is the fact that the maximum temperature for growth of mycelium under controlled laboratory conditions is 32° C. (2,7). The maximum temperature for the germination of ascospores and conidia is between 33° and 36° C. (1). Nevertheless, the successful inoculations in this experiment occurred between May 30 and September 2, 1953, a period in which temperatures of 32° C. and above were recorded on 31 days (8). Furthermore, after September 2, no successful inoculations were made, yet the four highest temperatures recorded were only 29.5° (September 29), 33° (October 2), 30.5° (October 14), and 31° C. (October 15).

The period during which successful inoculations were most frequent coincided with the period of greatest physiological activity in the host. Additional studies are needed to explore this phenomenon.

The extent to which precipitation affects the number of successful inoculations is not known. Regular precipitation was present from February 1 to March 28, 1953, during which no infection occurred, and from April 25 to August 28, when the largest number of successful inoculations was observed. The precipitation from October 1 to November 18 was only 0.09 inch and no infection occurred. Further observations are needed to determine the extent to which, if any, precipitation is a factor in infection.

Other microorganisms often crowd out E. fagacearum in culture. This crowding out, along with possible fungistatic and/or fungicidal activities of associated microorganisms, may be partly responsible for the failure to obtain infection when trees were inoculated with fragments of mats and pads from diseased trees.

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IOWA AGRICULTURAL EXPERIMENT STATION, AMES, IOWA

A RUST DISEASE OF THE SMOKE-TREE NEW TO NORTH AMERICA

G. E. Thompson

The first observations and collections of a rust disease new to North America on the smoke-tree, Cotinus coggygria Scop. (Rhus cotinus L.), were made on June 25, 1956. The tree is located in a shady ravine on the campus of the University of Georgia, Athens, Georgia and was planted about 40 years ago along with a number of other exotics. A few days later, the disease was found on another tree located on private property in the city.

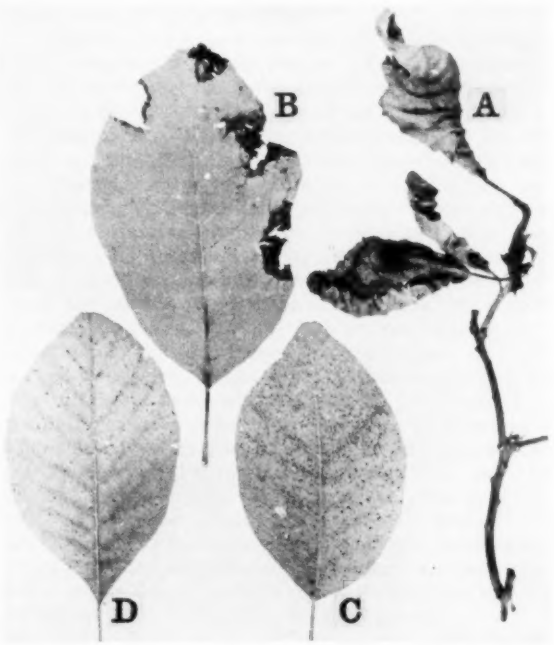

FIGURE 1. A. Aecial infection on terminal bud and leaf petiole showing enlargement and curvature of a leaf petiole. B. Aecial infections on a leaf. C. Minute dark spots bear uredinia on the lower surface of the leaf. D. telia on the upper surface.

When the disease was noticed, about 75 percent of the leaves showed conspicuous spots which were characterized by hypertrophied centers surrounded by dead tissue (Fig. 1, B). About 25 percent of the twig tips and leaf petioles were abnormally enlarged and usually curved downwards or to one side (Fig. 1, A). The infected twigs were dead so that the tree appeared to be affected by a blight. A few infections were present on the flower pedicels. The necrosis surrounding the primary infections was probably due to a species of Gloeosporium which was fruiting abundantly in the dead tissues.

Masses of aeciospores were present on the underside of the swollen portion of the leaf infections and over the surfaces of the enlarged twigs, leaf petioles, and flower pedicels. The collections were too late to show the true nature of the aecia, although they appeared to be of the caeoma type. Likewise, the spermogonial stage could not be accurately observed.

Uredinia with urediniospores were produced on the lower surface of the leaves in dark spots about 0.5 to 1 mm. in diameter (Fig. 1, C). Occasionally, the spots coalesced to form larger lesions. A few uredinia were observed on the remains of the flower pedicels. Telia with teliospores were just beginning to develop. They were evident on the upper surface of the minute leaf spots (Fig. 1, D).

As far as the writer has been able to determine, the only other report of a rust on this host is of Pileolaria cotini-coggyriae described by Tai and Cheo[1] in China. Although the American rust differs in certain respects from their rust, it is being referred to that species

[1] Tai, F. L., and C. C. Cheo. 1937. Notes on Chinese fungi VIII. Bul. Chinese Botanical Soc. 3:59.

at the suggestion of Dr. G. B. Cummins, who kindly compared it with type specimens of the Chinese rust.

A more complete account will be published when the taxonomy of the fungus has been established and additional observations have been made on the spermogonial and aecial stages.

DEPARTMENT OF PLANT PATHOLOGY, COLLEGE EXPERIMENT STATION, ATHENS, GEORGIA

THE ROLE OF PLANT DISEASES IN WILDLIFE FOOD PLANTS: A SMUT ON DOTTED SMARTWEED[1]

C. L. Fergus, W. M. Sharp, and Eugene Decker[2]

Research concerning the relation of plant diseases to wildlife food plants is a neglected, yet potentially fruitful field of investigation. Initial phases of such undertakings require that wildlife managers become aware that diseases of wildlife food and cover plants are a potential menace and that causative organisms of disease be determined. Further, valid estimates of losses incurred to wildlife food and cover are needed in order to initiate control measures where economically feasible.

Mycologists have collected and recorded fungi occurring on plants for a long time, regardless of whether the plant was or was not of economic importance. Therefore, there are available lists of fungi collected on plants. The two most extensive lists are the Host Index of the Fungi of North America (3) and the Index of Plant Diseases in the United States (4, 5). Plants of importance to wildlife as a food source or shelter may or may not be listed. To imply, however, that such lists are complete would be incorrect.

The estimation or evaluation of destruction caused by diseases of wildlife food plants has been ignored. Certainly no attempts comparable to those for crop plants have been made. Indeed, estimates for losses in the latter have been fragmentary and have lacked standardization resulting in defects in our knowledge of plant losses due to disease (1). Pearce and Spaulding (2) attempted to rate the seriousness of the principal destructive diseases of forest trees and shrubs in northeastern forests, but additional reports are "nonexistent". It is obvious, however, that such a virulent, killing disease as chestnut blight must have affected significantly the food habits and the number of game animals that used the chestnut as a staple part of their diet. What about diseases affecting wildlife food plants in ways other than death? What effect do these diseases have? The fruit yields of wild grapes, a valuable game food, for example, may be reduced appreciably by diseases affecting the fruits. Data evaluating the losses incurred by herbs and shrubs of importance to wildlife are nonexistent.

Smartweed (Polygonum punctatum Ell.) seed production in the Conneaut Marsh, Crawford County, Pennsylvania, was studied in 1953 by the Pennsylvania Cooperative Wildlife Research Unit. During the course of this study it was observed that a number of plants were infected with a smut. Examination revealed that the fungus was Ustilago utriculosa (Nees.) Ung. Although it had been found on various species of Polygonum this was the first time it had been collected on dotted smartweed in Pennsylvania. All the ovaries on the spike were killed and the tissue was replaced by fungus spores.

Dotted smartweed seed is an important waterfowl food. The plant occurs in almost pure communities in certain areas in Pennsylvania. The study area consisted of about 425 acres. Sixteen plots, 1 yard square, were set up in the center of the study area. The crop of mature seed reached its peak of abundance during the second week of September, at which time the fruiting spikes were collected. The composition of the community was: Polygonum punctatum 50 to 75 percent; Sagittaria latifolia 25 to 50 percent; Sparganium eurycarpum 0 to 5 percent; and traces of Pontederia cordata, Scirpus validus and Typha latifolia. On the basis of yields from the plots, seed production per acre was calculated to be 69.3 pounds. This figure is probably conservative, since no adjustment was made for the mature seed that had dropped prior to collection. Therefore, it is obvious that this plant is an important waterfowl food source.

Observations showed that 5 of the 16 sample plots contained spikes infected with smut. The smut had ruined from 5 to 50 of the spikes in each of these plots. The average number of spikes per plot was 373, and the average number of smutted spikes was 21, or 5.6 percent. Since the seed crop was heavy and the percentage of infected spikes low, the loss was not serious, but if the disease were to become prevalent and environmental conditions were appropriate for the development of the smut, an epiphytotic could result with a decrease of a

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[1] Contribution No. 75 of the Pennsylvania Cooperative Wildlife Research Unit, and No. 203 of the Department of Botany and Plant Pathology. Authorized for publication December 17, 1955, as paper No. 2032 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Associate Professor of Botany and Plant Pathology, Leader of The Pennsylvania Cooperative Wildlife Research Unit, and Research Assistant of the Department of Forest Management, respectively.

valuable waterfowl food. If these events occurred during years in which smartweed seed production was low, the effect could cause a total crop failure.

There is a great need for more studies to determine accurately how seriously certain fungus diseases affect wildlife food and cover plants. In the past 3 years, hawthorns (Crataegus spp.) have been rendered valueless as fruit producers, indeed they appear to be unable to survive in a healthy condition in certain localities in Pennsylvania. Under certain conditions, direct inexpensive methods of disease control might be necessary and appropriate. It is sincerely suggested that future wildlife studies include attempts to discover what diseases are present in a given study area and to what extent the wildlife food and cover values are affected.

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4. Weiss, F., compiler. 1950. Index of plant diseases in the United States. U. S. Dept. Agr., Plant Disease Survey, Special Publ. No. 1: part 1 (Acanthaceae-Compositae); part 2(Convolvulaceae-Gnetaceae); part 3 (Gramineae).
5. Weiss, F., and Muriel J. O'Brien, compilers. 1952-1953. Index of plant diseases in the United States. U. S. Dept. Agr., Plant Disease Survey, Special Publ. No. 1: part 4 (Guttiferae-Phytolaccaceae); part 5 (Pinaceae-Zygophyllaceae).

THE DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, THE PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PENNSYLVANIA

BOOK REVIEW

"PRINCIPLES OF FUNGICIDAL ACTION", by James G. Horsfall. xx + 279 pages. 1956. Waltham, Mass.: The Chronica Botanica Co.; New York City: Hafner Publishing Co. Price $6.50.

This book is a surprisingly clear and interesting presentation of the complex subject matter. The author is one of the foremost as well as most original students of the subject, so that this review and analysis are soundly based on his own experience. His discussion is not dogmatic, however; on controversial or undecided questions he gives all significant viewpoints.

The outstanding impression is of the continuous evolution of speculation and knowledge about what fungicidal chemicals actually do to fungi and the means by which they achieve their toxic action. It is evident that scarcely any of the problems have definitely been solved so far.

The scope of the book includes chemical protection of fabrics, timber, etc., against decay as well as of living plants against disease. The introductory chapter contains a historical summary and some definitions. Chapter II takes up fungicidal action and its measurement; Chapter III, protection and its measurement; Chapter IV, mobilization of a residual protectant; Chapter V, permeation into the fungus; Chapter VI, disruption of cellular organization; Chapter VII, effect on mitosis, morphology, and growth; Chapter VIII, effect on metabolism of the fungus; Chapter IX, chelation of needed metals; Chapter X, the action of metals; Chapter XI, the action of sulfur: Chapter XII, the action of organic sulfur compounds; Chapter XIII, action of quinones and other ketones; Chapter XIV, the action of heterocyclic compounds; Chapter XV, the chemotherapy of plant diseases. The bibliography occupies 28 pages and there are both general and author indexes. -- (Paul R. Miller and Jessie I. Wood, Plant Disease Epidemics and Identification Section)

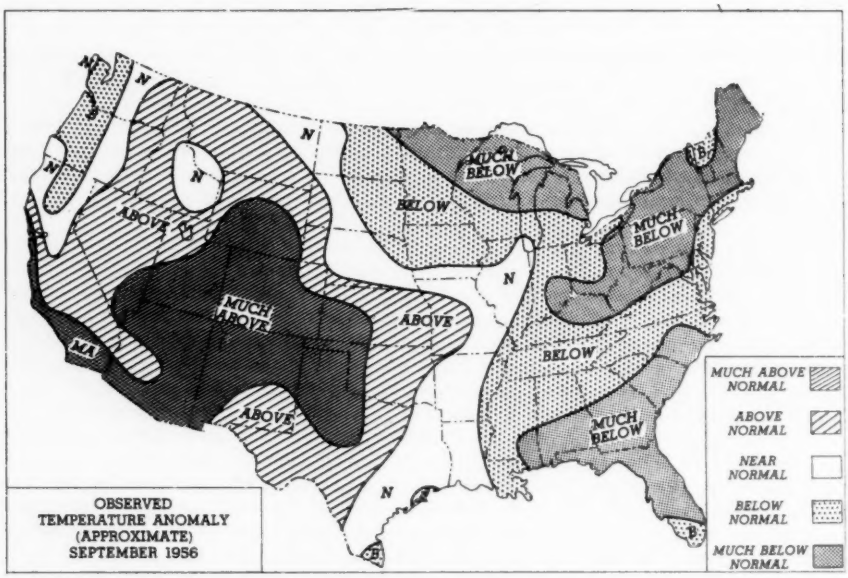
ANNOUNCEMENT:

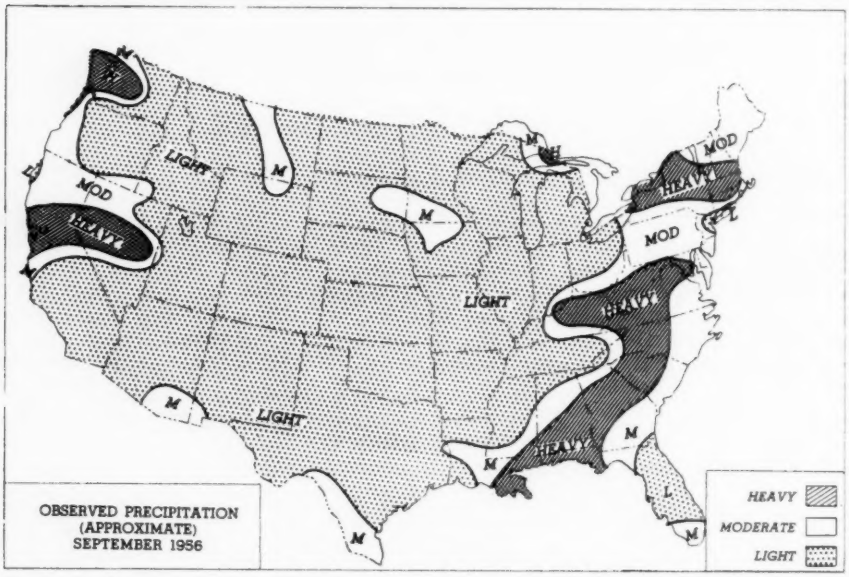
GRASSLANDS PROGRAM OF SECTION O (AGRICULTURE)

AT THE A. A. A. S. ANNUAL MEETING

The American Phytopathological Society is among the co-sponsors of the Section O program on "Grasslands in Our National Life", scheduled at the Hotel Martinique, December 27-30.

The daytime sessions on December 29 and 30 are planned as a symposium, with invitation papers to present a comprehensive discussion of grassland research. Two papers are of special interest to plant pathologists: K. W. Kreitlow, on "Disease control in grasslands in the temperate humid region", afternoon session, December 29; and Martin G. Weiss, on "Integration of programs in genetics, pathology, and entomology for progress in grasslands research", morning program, December 30.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.